Appendix F

Stormwater Calculations

1.0 OBJECTIVE

These calculations demonstrate the adequacy of the proposed stormwater management structures at the Bremo Power Station for the CCR Surface Impoundment closure project. The stormwater structures include drainage channels, culverts, and dry detention basins. These calculations were completed in accordance with the Virginia and Fluvanna County stormwater requirements.

The site contains three inactive CCR impoundments: the East Ash Pond, the North Ash Pond, and the West Ash Pond. The East Ash Pond was previously covered with intermediate cover soil. The North and West Ash Ponds are currently exposed and contain impounded water and CCR.

2.0 VIRGINIA RUNOFF REDUCTION METHOD

The site was analyzed for pollutant removal in accordance with the Virginia Runoff Reduction Method (VRRM). The Virginia Department of Environmental Quality's (DEQ) VRRM spreadsheet was used to calculate the required phosphorus reduction.

The Bremo Power Station encompasses a total site area of 284 acres, with the CCR surface impoundment closure affecting a total disturbed area of 142.28 acres. Based on data in the National Resources Conservation Service's (NRCS) Web Soil Survey (WSS), the site contains predominantly hydrologic soil group (HSG) B soils. The pre-redevelopment area consists of 125.22 acres of forested/open space, 57.49 acres of managed turf, and 101.29 acres of impervious area. The existing CCR impoundments were considered impervious area for this analysis. The post-redevelopment (closed CCR impoundments) condition consists of 110.78 acres of forested/open space, 142.71 acres of managed turf, and 30.51 acres of impervious cover.

Based on these conditions, the pre-redevelopment total phosphorus load is 254.25 lb/yr. The post-redevelopment condition, due to the conversion of large impervious areas to managed turf, has a total phosphorus load of 138.78 lb/yr. Because the post-redevelopment condition reduces the total phosphorus load by more than the required 20% (203.40 lb/yr), no additional total phosphorus load reduction is needed for the site. No pollutant-removal best management practices (BMPs) were included in this design.

3.0 HYDROLOGY

3.1 Precipitation

Precipitation estimates were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Point Precipitation Frequency Database for the 24-hour precipitation events. The 1-year, 2-year, 10-year, 25-year, and 100-year event precipitations were used for the site's hydrologic and hydraulic calculations. The precipitation depths (in inches) are shown in the table below.

24-hour Event	Precipitation (in)
1-year	2.63
2-year	3.19
10-year	4.82
25-year	5.93
100-year	7.91

3.2 Drainage Areas

The site was evaluated by drainage area, as shown in the Stormwater Plan Drawings (SWM-2 and SWM-3). Each drainage area was assigned a composite curve number (CN) based on the composition of its land cover – the table below shows the CN values selected for each land cover type.

Land Cover	CN
Heavy Woods	55
Brush	48
Meadow	58
Gravel	91
Exposed CCR	91
Water	98

Using the NRCS lag time equation, shown below, lag times were calculated for the overland flow areas of each drainage area. Travel times for channelized flow were added to the computed overland lag times to develop a composite lag time for each drainage area. The NRCS lag time equation is:

$$T_L = \frac{L^{0.8}(S+1)^{0.7}}{1900Y^{0.5}}$$

Where T_L is the lag time in minutes, L is the length of flow, S is equal to $\frac{1000}{CN+1} - 10$, and Y is the average slope. The drainage areas, their size, CN value, percentage of impervious area, and composite lag times are shown in the table below. Note that the total drainage area evaluated is larger than the site area due to offsite contributing drainage (Area 4b) that contributes flow directly to the 48" stone arch culvert.

Drainage Area	Area (Ac.)	CN	% Impervious	Lag Time (min)
Existing Conditions				
Area [01]	103.31	75	54%	12
Area [02]	42.99	57	4%	15
Area [03a]	14.07	54	3%	13
Area [03b]	14.01	55	5%	6
Area [03c] *	9.66	58	0%	N/A *
Area [04a]	5.22	58	9%	14
Area [04b]	306.50	51	0%	44
WP1 **	18.84	91	100%	N/A **
WP2	10.14	56	2%	65
WP3	3.80	58	2%	11
** Area [03c] represents the east ash pond top surface that does not discharge*				
*** Area WP1 represents the west ash pond surface that discharges through Outfall 002*				
Proposed Conditions				
Area 1a	17.32	58	0%	17
Area 1b	3.40	58	0%	9
Area 1c	11.67	56	0%	16
Area 1d	14.07	57	0%	13
Area 1e	3.83	58	0%	15
Area 1f	2.96	57	0%	11
Area 1g	16.95	55	0%	10
Area 1h	13.36	58	0%	15
Area 1i	12.57	58	0%	14
Area 1j	7.18	57	0%	8
Area [02]	42.81	57	4%	15
Area 3a	9.48	56	0%	4
Area 3b	1.66	60	5%	8
Area 3c	8.68	57	0%	4
Area 3d	3.39	57	9%	5
Area 3e	2.54	56	2%	8
Area 3f	10.68	58	0%	19
Area 3g	4.99	60	6%	10
Area 4a	2.76	58	11%	1
Area 4b	306.20	51	0%	44
WP2a	9.70	56	3%	73
WP2b	14.03	58	0%	44
WP3	3.35	58	2%	11

4.0 HYDRAULICS

The pre-development and post-development conditions were modeled using the U.S. Army Corps of Engineers Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). The pre-development conditions were evaluated for comparison to the post-development flows. The post-development flows were used to determine the flows in each stormwater structure during the design storm events.

4.1 Channels

The channel flows were analyzed in accordance with Minimum Standard 19 (MS-19) as listed in 9VAC25-840-40. The 2-year channel velocities were designed to be non-erosive for the proposed channel lining material (grass, stabilization matting, etc.), and all of the channels contain the calculated flow from the 10-year storm event. The channels were also evaluated for the 25-year storm event in accordance with the Virginia Solid Waste Management Regulations (VSWMR); all channels contain the 25-year event. The anticipated channel flows, 2-year velocities, and 10-year and 25-year flow depths are listed in the table below.

Channel				2-year		10-year		25-year	
Name	Channel Depth*	Lining Material	Drainage Area	Flow	Velocity	Flow	Depth	Flow	Depth
	(ft)		*(ac)*	*(cfs)*	*(ft/s)*	*(cfs)*	*(ft)*	*(cfs)*	*(ft)*
Stone Arch Culvert	10	Existing Vegetation	496.64	12.90	1.46	76.30	2.32	150.26	3.43
NP Out A	3	Rip-rap/Gabions	103.04	14.30	1.85	82.40	1.85	141.90	2.48
NP Out B	3	Rip-rap/Gabions	103.04	14.30	6.23	82.40	0.62	141.90	0.85
Reach-1aa	2	Grass/EC-3	69.76	9.20	1.91	53.50	1.13	91.40	1.50
Reach-1ab	2	Grass/EC-3	52.48	6.70	1.71	40.10	0.96	68.20	1.28
Reach-1b	2	Grass/EC-3	49.28	6.70	1.71	42.50	0.99	76.90	1.37
Reach-1da	2	Grass/EC-3	37.76	5.40	1.55	34.20	0.89	61.60	1.22
Reach-1db	2	Grass/EC-3	23.68	3.20	1.27	21.20	0.68	38.50	0.94
Reach-1dc	2	Grass/EC-3	7.04	1.20	1.67	6.60	0.34	11.60	0.46
Reach-1ha	2	Grass/EC-3	33.28	6.00	1.63	31.70	0.84	55.40	1.15
Reach-1hb	2	Grass/EC-3	19.84	3.80	1.40	19.70	0.65	34.20	0.88
Reach-1ia	2	Grass/EC-3	19.84	3.80	1.40	19.80	0.65	34.40	0.88
Reach-1ib	2	Grass/EC-3	7.04	1.60	1.01	8.40	0.40	14.60	0.55
Reach-3ca	2	Grass/EC-3	173.44	31.60	1.82	145.60	1.05	245.80	1.42
Reach-3cb	2	Grass/EC-3	171.52	31.40	2.69	144.80	2.58	244.40	3.29
Reach-3d	2	Grass/EC-3	151.68	29.40	2.64	134.10	2.49	225.70	3.18
Reach-3e	2	Grass/EC-3	45.44	16.30	2.21	58.20	1.66	5.20	2.06
Reach-4a	2	Grass/EC-3	7.68	2.70	1.89	8.00	0.78	12.60	1.09
Reach-WP2a	2	Rip-rap/Gabions	23.74	0.89	1.56	3.19	0.27	5.36	0.36
Reach-WP3a	2	Rip-rap/Gabions	3.33	0.90	1.22	3.90	0.50	6.60	0.67

* Channel depth is defined as depth of the lining material. Actual constructed channel depths are greater.

4.2 Culverts

The site contains three proposed culverts: one 48-inch reinforced concrete pipe (RCP) culvert at the North Ash Pond Access Road, one 10'x10' box culvert draining the North Ash Pond, and one 24-inch RCP on the south side of the East Ash Pond. One existing 48-inch stone arch culvert downstream of the East Stormwater Detention Pond flows under the CSX Railroad tracks to the eastern outfall. The culvert profiles are shown on drawing SWM-6 of the Closure Plan Drawings. The table below summarizes the flows for the four culverts.

Culvert	Size	Q_2	Q_{10}	Q_{25}
		(cfs)	(cfs)	(cfs)
NP Culvert 1	48" dia	6.80	40.20	68.20
North Pond Discharge	10'x10'	14.30	82.50	142.10
EP Culvert 2	24" dia	2.10	5.80	8.50
Stone Arch Culvert	48" dia	12.93	76.33	150.27

4.3 East Stormwater Detention Pond

The proposed East Pond was designed as a dry detention pond, with the primary purpose of controlling the stormwater discharge rate from the North and East Pond Drainage areas. The discharge structure consists of a cast-in-place reinforced concrete tower located in the southern embankment. A 12" HDPE pipe at the pond bottom (elevation 206.0) controls smaller flows (2-year and smaller). A 10-inch orifice is located on the discharge tower at elevation 216.0 ft and adds capacity for storm events up to the 25-year, 24-hour storm event. A third discharge elevation, consisting of a 2-foot wide rectangular weir, is located in the discharge tower at elevation 223.0 ft and provides discharge capacity for storm events up to and including the 100-year, 24-hour storm event. The pond's emergency spillway at crest elevation 228.0 ft, consists of a 230-foot wide trapezoidal weir with 3:1 sideslopes. The weir is armored with riprap and provides discharge capacity for storms larger than the 100-year event. Pond discharges for each of the analyzed storm events are shown in the Attachment as well as on Drawing SWM-6 of the Closure Plan Drawings.

East Detention Pond Routing Summary

Pond Summary Results	2-year	10-year	25-year	100-year
Peak Inflow (CFS)	32.07	147.98	249.83	443.61
Peak Outflow (CFS)	6.08	13.35	18.61	88.60
Peak Elevation (ft)	210.97	218.12	223.03	227.66
Spillway	0.00	0.00	0.00	0.00

4.4 West Stormwater Detention Pond

The West Stormwater Detention Pond receives runoff from a portion of the former West Ash Pond area, and has the primary purpose of controlling the stormwater discharge rate prior to discharging through an existing manmade channel into Holman Creek. The discharge structure consists of a 36-inch riser structure with a 3-inch dewatering orifice. The top of the riser structure is located at elevation 215.5 feet, and the orifice is located at elevation 213.0 feet (bottom of pond). There is no emergency spillway as the primary riser structure adequately handles the 100-year flow event. The riser structure discharges through a 24-inch RCP pipe into an existing manmade channel that flows into Holman Creek. Pond discharges for the West Stormwater Detention Pond are shown in the Attachment as well as on Drawing SWM-6 of the Closure Plan Drawings. Channel adequacy for the West Stormwater Detention Pond is discussed in Section 5.2.

West Stormwater Detention Pond Routing Summary

Pond Summary Results	2-year	10-year	25-year	100-year
Peak Inflow (CFS)	2.00	8.50	14.60	27.70
Peak Outflow (CFS)	0.50	6.80	12.70	23.50
Peak Elevation (ft)	215.50	215.80	216.10	216.60

4.5 Canal Pond

The Canal Pond is formed between the embankment of the East Detention Pond and the CSX Railroad embankment. Discharge from the canal pond is through an existing 48-inch stone arch culvert to the James River. The canal pond and stone arch culvert model was used to evaluate the discharge from the East Detention Pond to show that the proposed design did not cause an increase in water levels, increase the discharge rate through the 48-inch stone arch culvert, nor overtop the CSX embankment (elevation 218). A summary of this evaluation is presented in Section 5.0.

Canal Pond Routing Summary

Pond Summary Results	2-year	10-year	25-year	100-year
Peak Inflow (CFS)	12.92	76.42	157.03	391.43
Peak Outflow (CFS)	12.92	76.33	150.27	251.06
Peak Elevation (ft)	199.71	202.65	206.12	214.66

4.6 West Treatment Pond

The West Treatment Pond is a 5.3-acre geomembrane-lined pond that discharges through the pond's concrete intake tower into a pipe system to Outfall 002 at the James River.

4.7 North Pond

The North Pond will be closed and capped with a geomembrane cap system and will no longer impound water. The North Pond was included in the model as a pond because it contributes a significant amount of runoff to the East Detention Pond. The 10'x10' concrete box culvert is designed to convey the drainage from the cap system without developing a stored pool of water on the cap. The inflow/outflow curves presented in the Attachment show this as overlapping curves.

North Pond Routing Summary

Pond Summary Results	2-year	10-year	25-year	100-year
Peak Inflow (CFS)	14.30	82.50	142.10	250.60
Peak Outflow (CFS)	14.30	82.50	142.10	250.50
Peak Elevation (ft)	306.10	307.50	308.40	309.80

5.0 OUTFALLS

The site outfalls (from the Stormwater Detention Ponds) must meet the water quantity requirements of 9VAC25-870-66, which state that the maximum post-development peak flow in a manmade channel for the two-year, 24-hour storm event must not be erosive. Each outfall must also meet the flood protection requirements of 9VAC25-870-66.C.1. The table below summarizes the pre- and post-development flows (cfs) through each of the outfall locations.

Condition	Design Flow	Eastern Outfall	Western Outfall
Pre-Development	Q_2	13.46	0.71
	Q_{10}	86.31	3.00
	Q_{25}	166.25	5.27
	Q_{100}	252.58	10.21
Post-Development	Q_2	12.93	0.51
	Q_{10}	76.33	6.78
	Q_{25}	150.27	12.66
	Q_{100}	251.06	23.45

5.1 Eastern Outfall

The existing 48-inch stone arch culvert discharges into a manmade discharge channel that drains into the James River south of the CSX Railroad embankment. The existing manmade discharge channel has a width of approximately 10 feet and is assumed to be a grass-lined channel. For this outfall analysis, the channel was modeled as having a bottom width of 10 feet, a side slope of 1:1, a depth of 10 feet, and a longitudinal slope of 0.2%. Assuming that the channel is dry, the anticipated 2-year discharge is 12.93

cfs, which results in a velocity of 1.50 ft/s and a depth of flow of 0.79 feet (using Manning's equation). This velocity is non-erosive for a grass-lined channel and satisfies the channel protection requirements.

While the channel may contain water from the James River, depending on the River's stage, this water level is not anticipated to cause flooding of the channel; therefore, flood protection for the outfall channel was analyzed based on the criteria for a non-flooded conveyance system (9VAC25-870-66.C.1.). The 10-year discharge through the channel is expected to be 76.33 cfs. Using the aforementioned channel dimensions, the 10-year velocity and depth of flow are expected to be 2.71 ft/s and 2.28 feet, respectively. As no localized flooding is caused by the post-development flow, the flood protection criteria are satisfied.

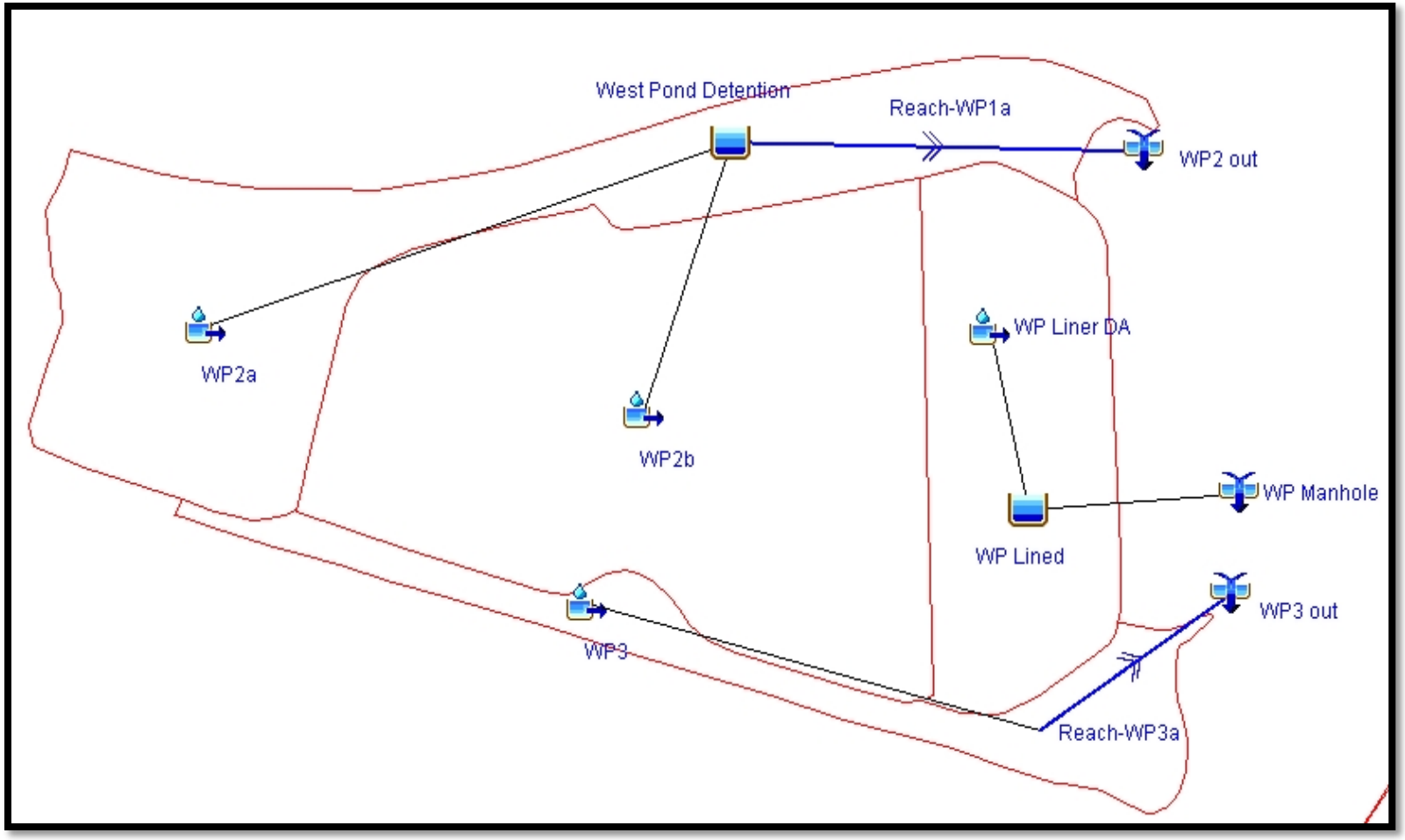
5.2 Western Outfall

The West Stormwater Detention Pond riser structure discharges through a 24-inch RCP into an existing manmade channel. The existing manmade channel is approximately v-shaped, has a longitudinal slope of 2.67%, and has side slopes of approximately 1.75:1. The channel is grass-lined and has a depth of approximately 4 feet. Using HEC-HMS modeling, the 2-year, 24-hour post-development discharge into the manmade channel is 0.513 cfs, resulting in a flow velocity of 2.08 ft/s. This velocity is non-erosive, and satisfies the channel protection criteria in 9VAC25-870-66.

The existing manmade channel discharges into Holman Creek, and does not experience localized flooding during the 10-year, 24-hour storm event. The post-development discharge into the manmade channel during the 10-year, 24-hour storm event is 6.78 cfs, which results in a flow depth of 0.99 feet. This flow depth is contained by the manmade channel, satisfying the flood protection criteria.

Attachment

Attachment 1 HEC-HMS Models and Stage-Storage-Discharge Curves

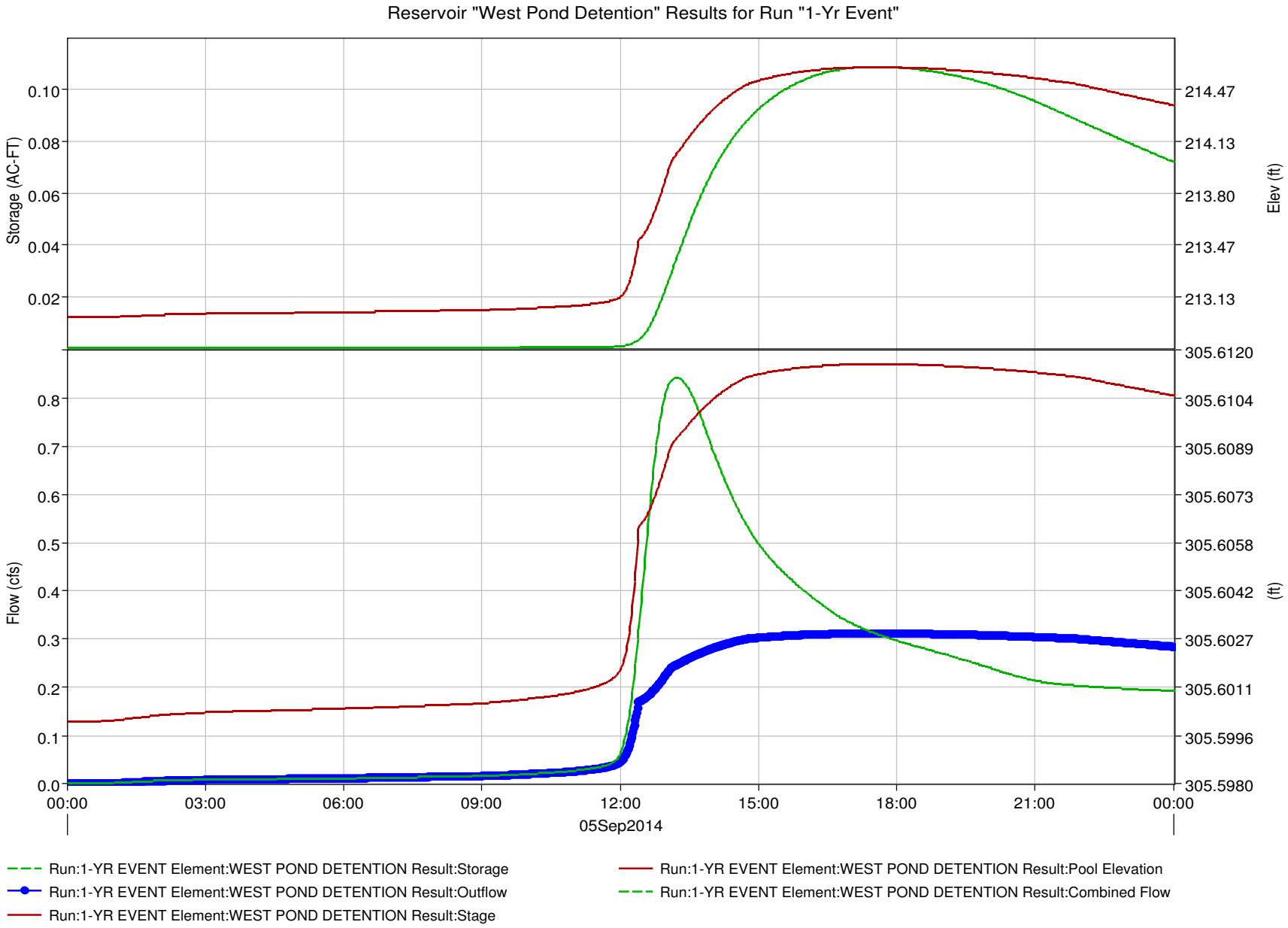


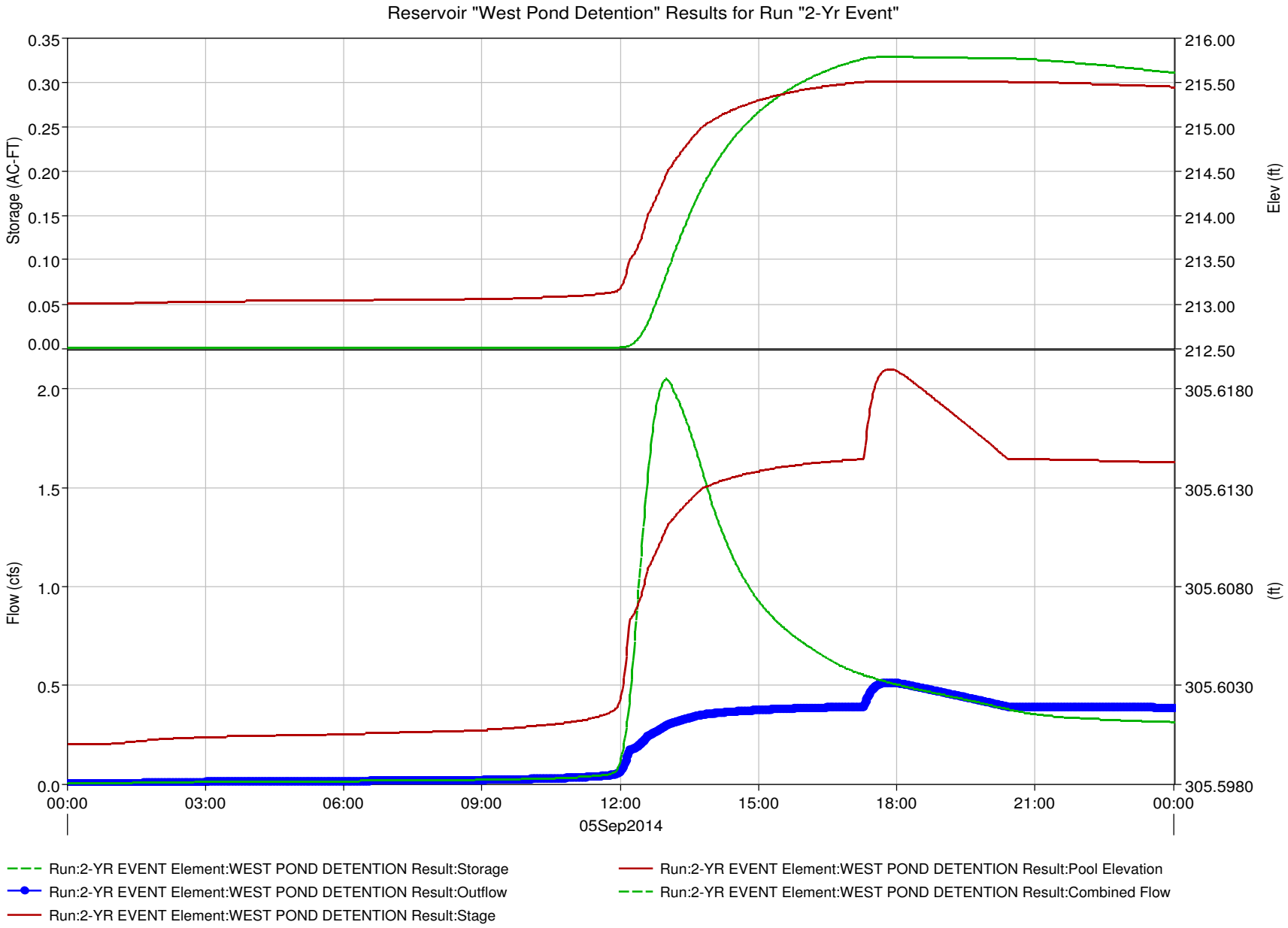
Model for West Treatment Pond - Proposed

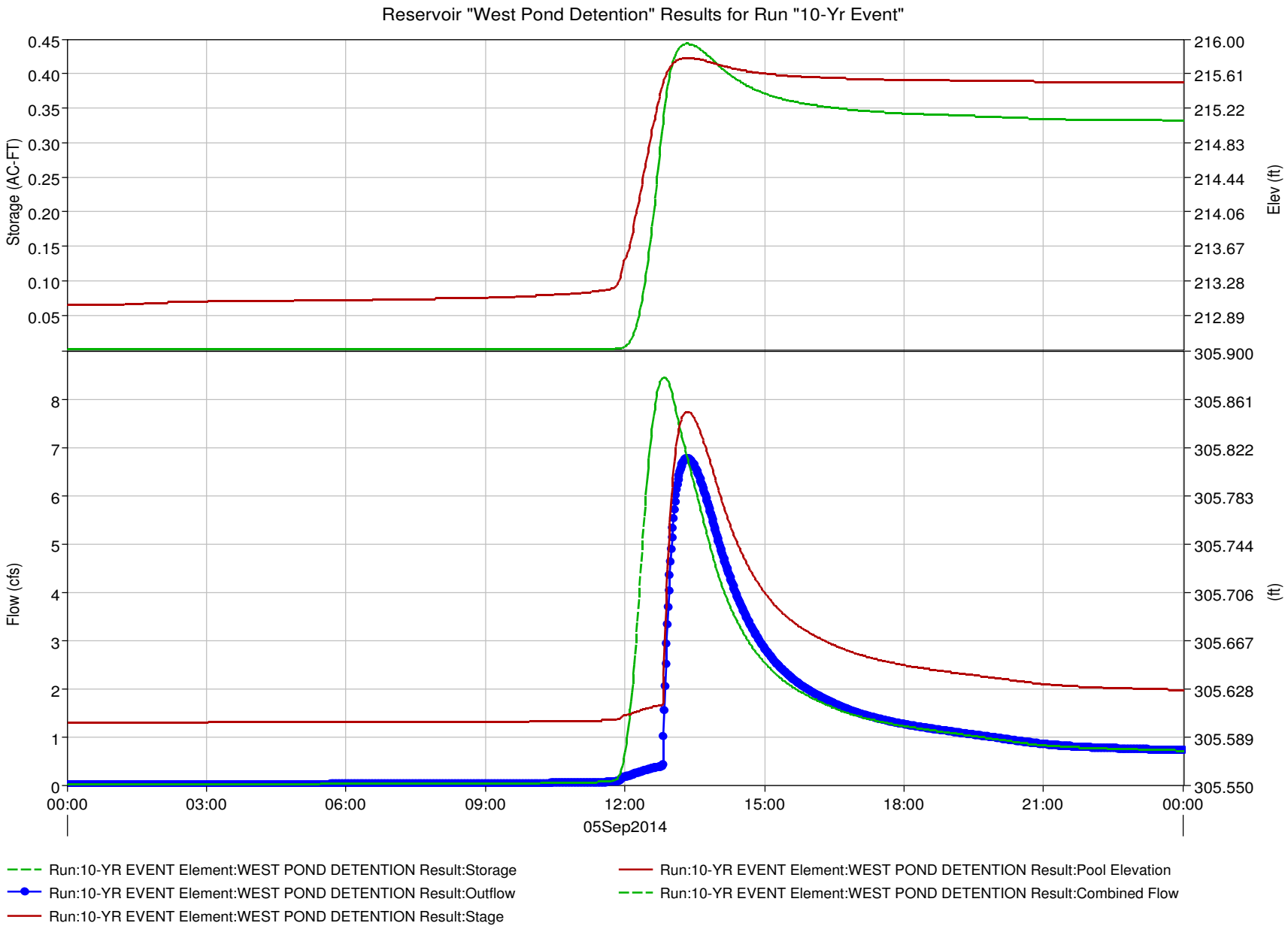
West Treatment Pond and West Detention Pond

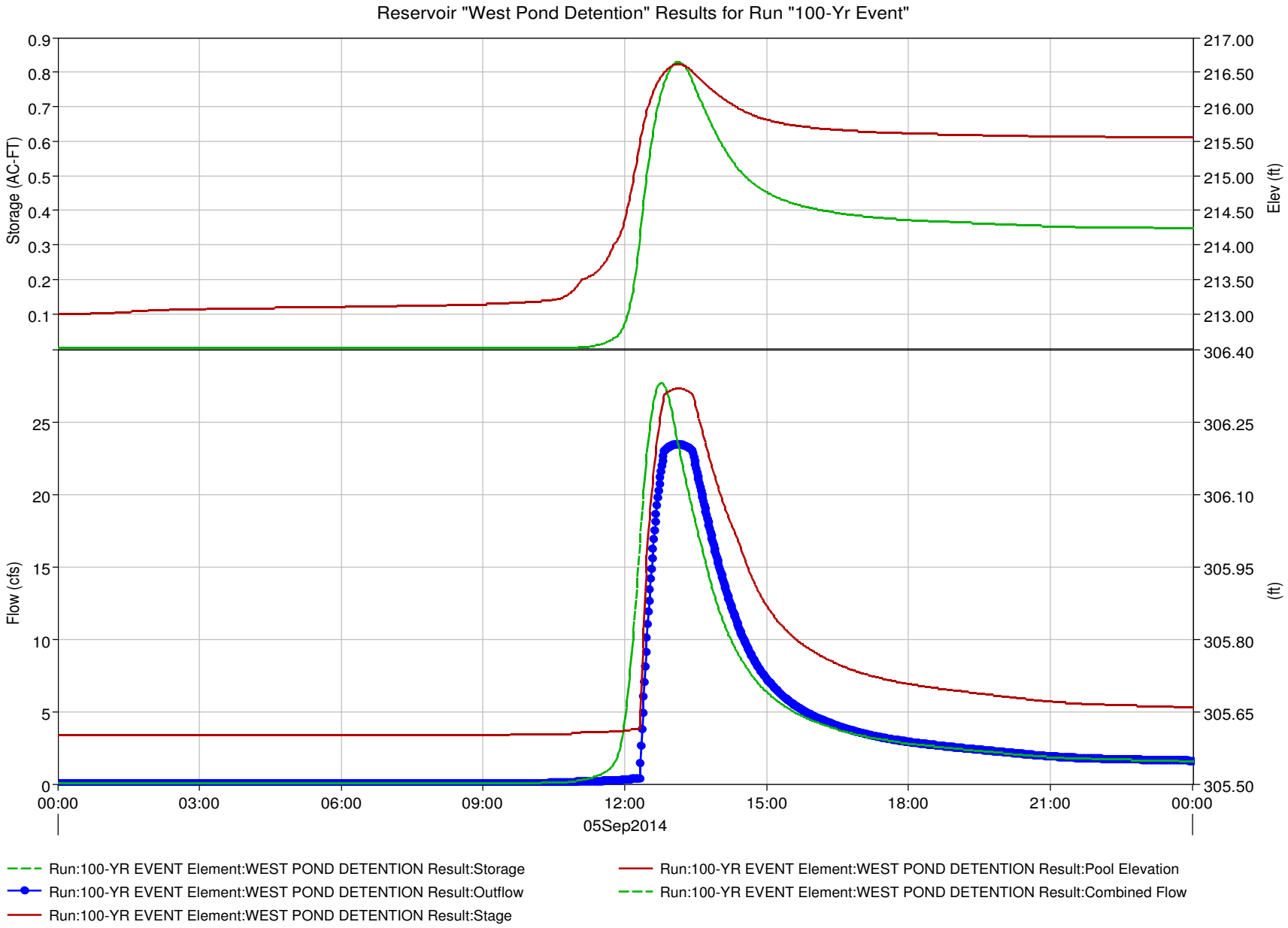
Post Closure Model Inputs			West Pond		
			WP2a	WP2b	WP3
Total Drainage Area (ac)			9.70	14.03	3.35
Land Coverage (ac)	Heavy Woods, CN =	55	3.75	0	0.93
	Brush, CN =	48	1.47	0	0
	Grass/Meadow, CN =	58	4.23	14.03	1.82
	Gravel/Impervious, CN =	91	0.25	0	0.06
	Exposed CCR, CN =	91	0	0	0
	Water Surface, CN =	98	0	0	0
Composit CN			56	58	58
Percent Impervious (%)			3%	0%	2%
Lag Time (min)			73	44	11

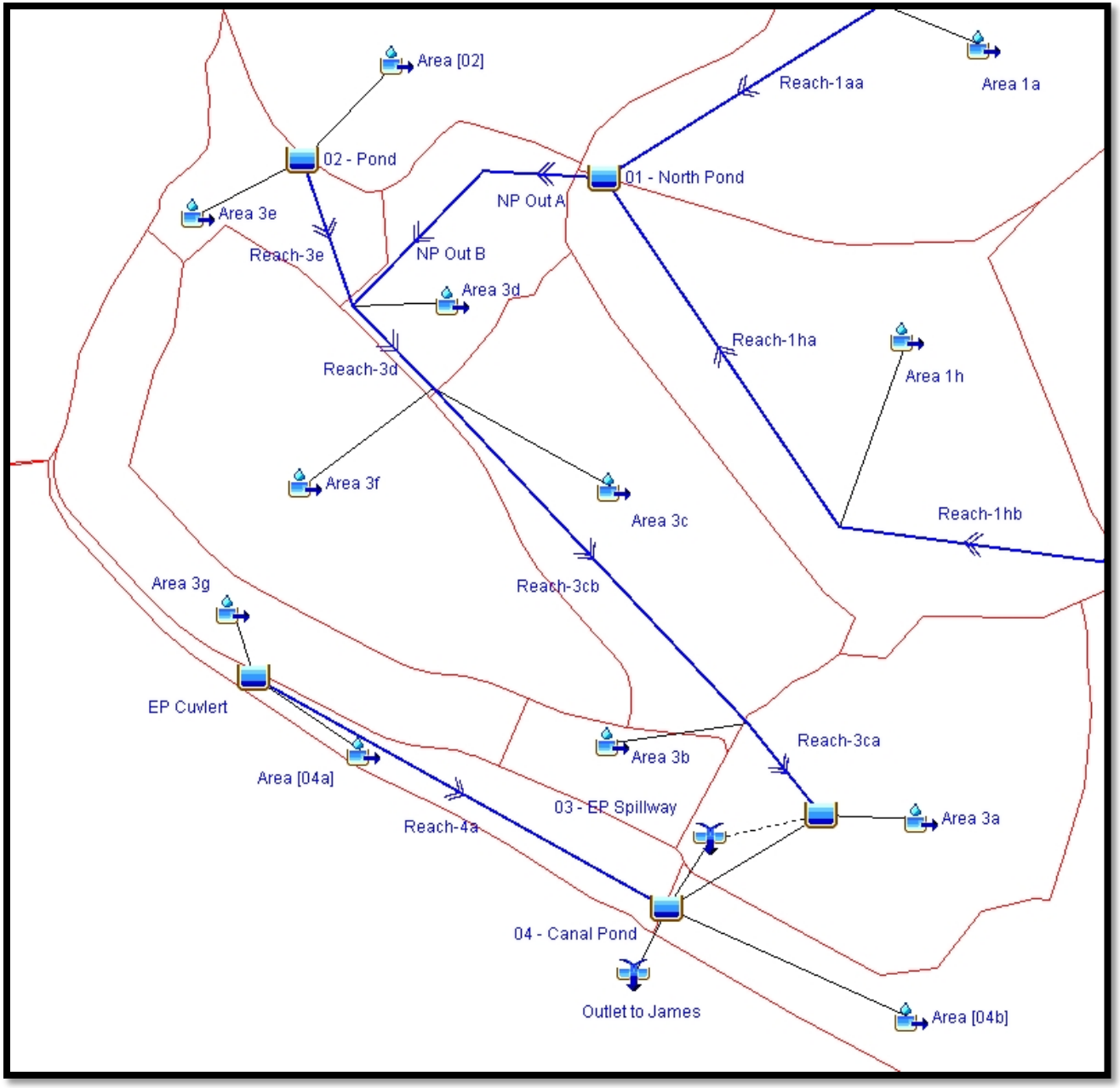
	Drainage Area	Peak Discharge (CFS)					
	DA (ac)	1-inch	1-year	2-year	10-year	25-year	100-year
WP Liner DA	5.89	7.10	18.80	22.80	34.50	42.50	56.60
WP Lined	5.89	0.30	2.00	2.60	4.30	5.50	7.40
WP2b	14.02	0.00	0.40	1.30	6.00	10.50	20.10
WP2a	9.73	0.10	0.40	0.90	3.20	5.40	9.90
West Pond Detention	23.74	0.10	0.30	0.50	6.80	12.70	23.50
Reach-WP1a	23.74	0.10	0.30	0.50	6.80	12.70	23.50
WP2 out	23.74	0.10	0.30	0.50	6.80	12.70	23.50
WP3	3.33	0.10	0.30	0.90	3.90	6.60	12.20
Reach-WP3a	3.33	0.10	0.30	0.90	3.90	6.60	12.10
WP3 out	3.33	0.10	0.30	0.90	3.90	6.60	12.10


Reservoir "West Pond Detention" Results for Run "1-Yr Event"
Storage (AC-FT)
0.10
0.08
0.06
0.04
0.02
Elev (ft)
214.47
214.13
213.80
213.47
213.13
305.6120
Flow (cfs)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
305.6104
305.6089
305.6073
305.6058
305.6042
305.6027
305.6011
305.5996
305.5980
(ft)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:1-YR EVENT Element:WEST POND DETENTION Result:Storage
Run:1-YR EVENT Element:WEST POND DETENTION Result:Outflow
Run:1-YR EVENT Element:WEST POND DETENTION Result:Stage
Run:1-YR EVENT Element:WEST POND DETENTION Result:Pool Elevation
Run:1-YR EVENT Element:WEST POND DETENTION Result:Combined Flow


Reservoir "West Pond Detention" Results for Run "2-Yr Event"
Storage (AC-FT)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Elev (ft)
216.00
215.50
215.00
214.50
214.00
213.50
213.00
212.50
Flow (cfs)
2.0
1.5
1.0
0.5
0.0
(ft)
305.6180
305.6130
305.6080
305.6030
305.5980
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:2-YR EVENT Element:WEST POND DETENTION Result:Storage
Run:2-YR EVENT Element:WEST POND DETENTION Result:Outflow
Run:2-YR EVENT Element:WEST POND DETENTION Result:Stage
Run:2-YR EVENT Element:WEST POND DETENTION Result:Pool Elevation
Run:2-YR EVENT Element:WEST POND DETENTION Result:Combined Flow


Reservoir "West Pond Detention" Results for Run "10-Yr Event"
Storage (AC-FT)
Elev (ft)
Flow (cfs)
(ft)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
216.00
215.61
215.22
214.83
214.44
214.06
213.67
213.28
212.89
305.900
8
7
6
5
4
3
2
1
0
305.861
305.822
305.783
305.744
305.706
305.667
305.628
305.589
305.550
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:10-YR EVENT Element:WEST POND DETENTION Result:Storage
Run:10-YR EVENT Element:WEST POND DETENTION Result:Outflow
Run:10-YR EVENT Element:WEST POND DETENTION Result:Stage
Run:10-YR EVENT Element:WEST POND DETENTION Result:Pool Elevation
Run:10-YR EVENT Element:WEST POND DETENTION Result:Combined Flow


Reservoir "West Pond Detention" Results for Run "100-Yr Event"
Storage (AC-FT)
Elev (ft)
Flow (cfs)
(ft)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
217.00
216.50
216.00
215.50
215.00
214.50
214.00
213.50
213.00
306.40
306.25
306.10
305.95
305.80
305.65
305.50
25
20
15
10
5
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:100-YR EVENT Element:WEST POND DETENTION Result:Storage
Run:100-YR EVENT Element:WEST POND DETENTION Result:Outflow
Run:100-YR EVENT Element:WEST POND DETENTION Result:Stage
Run:100-YR EVENT Element:WEST POND DETENTION Result:Pool Elevation
Run:100-YR EVENT Element:WEST POND DETENTION Result:Combined Flow

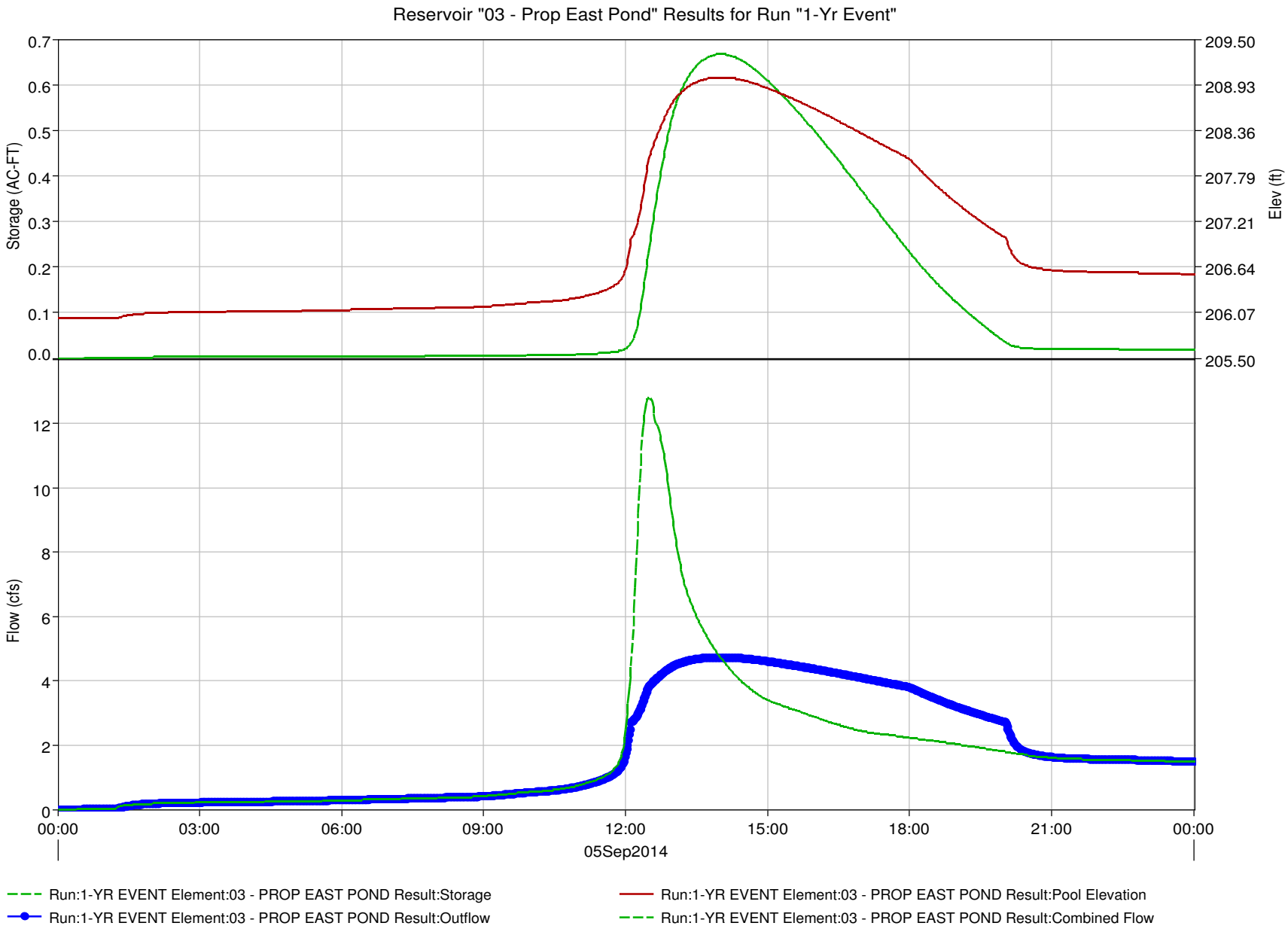


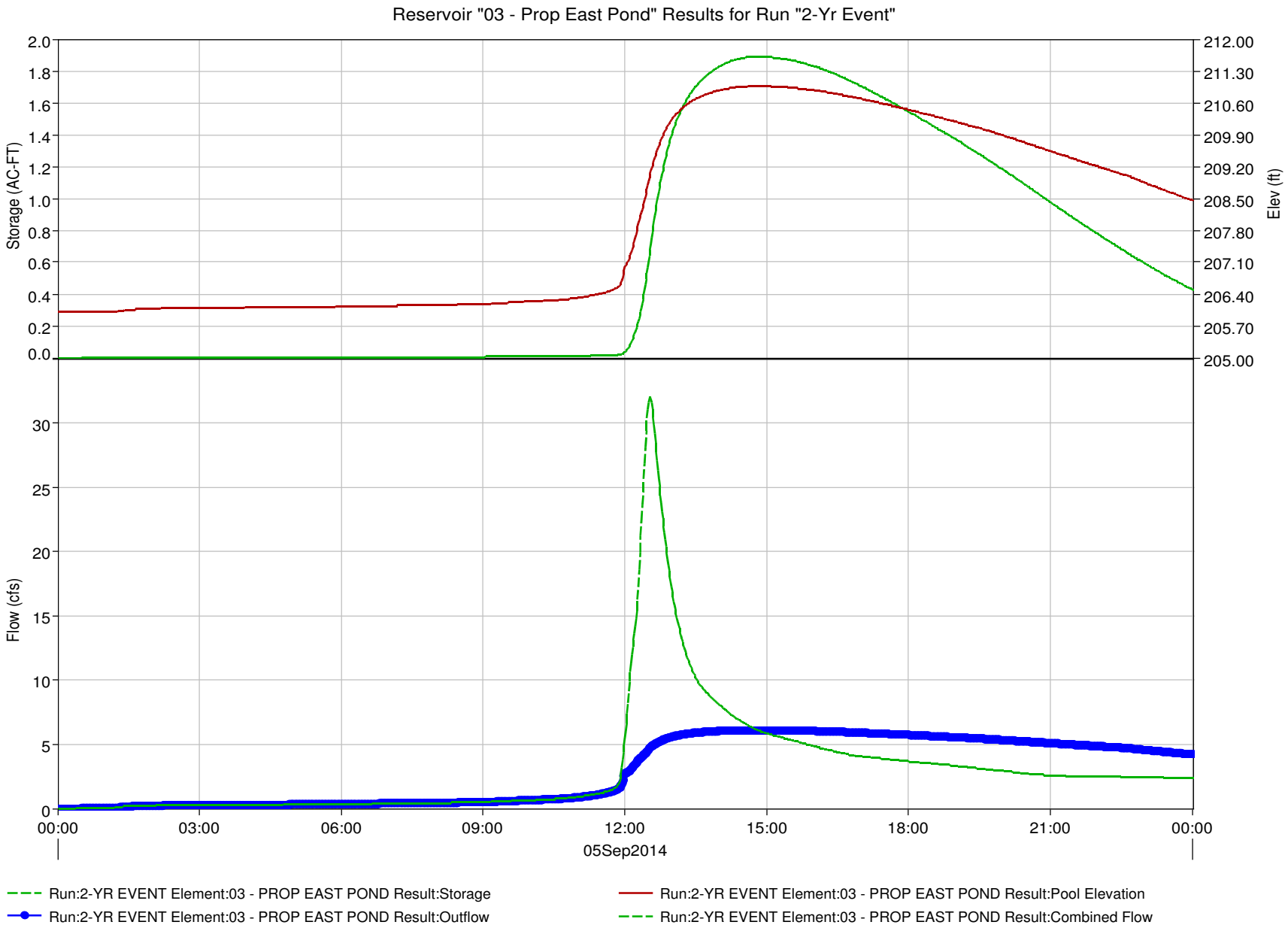
Model for East Pond – Proposed

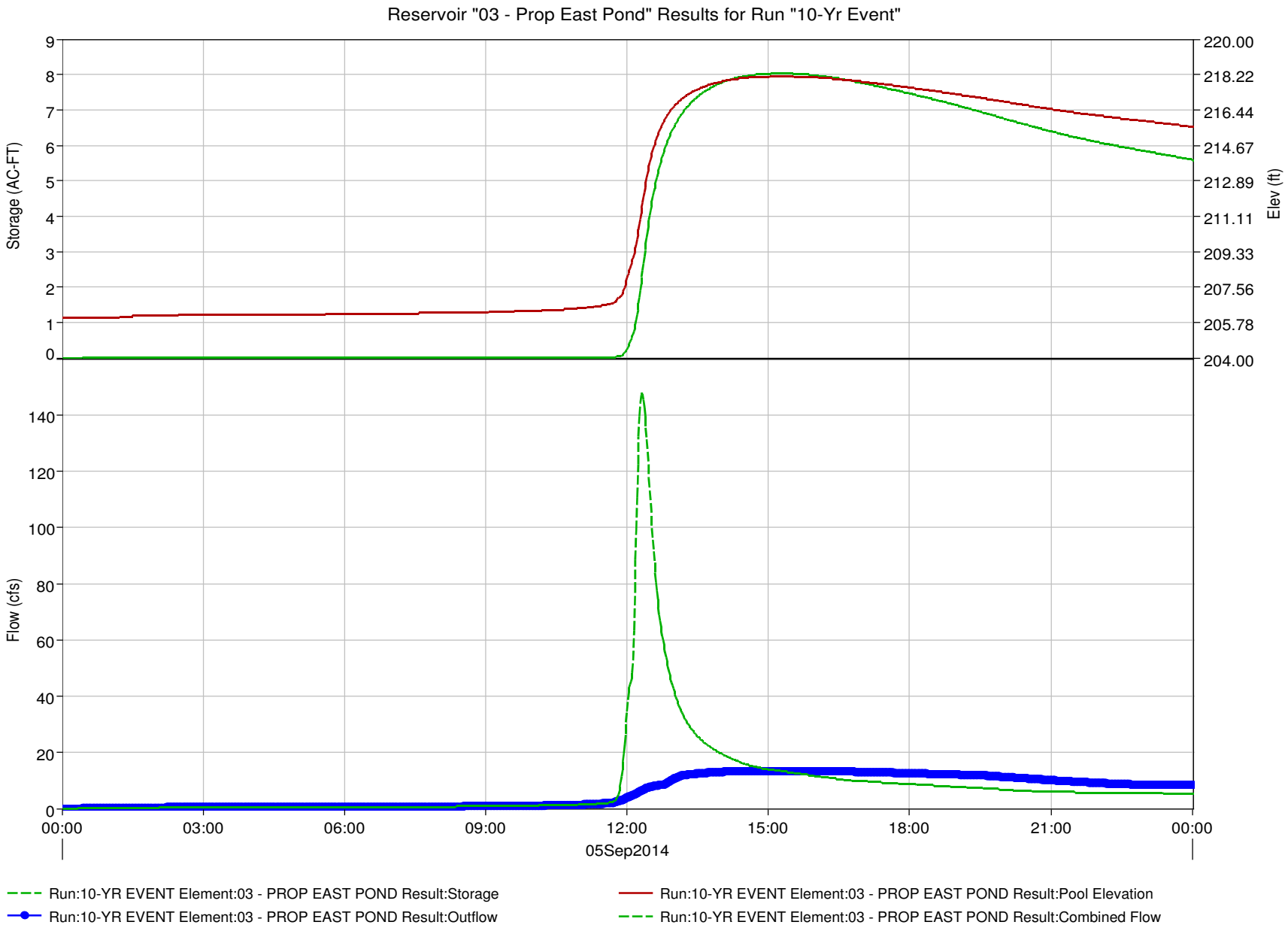
Canal Pond and East Detention Pond

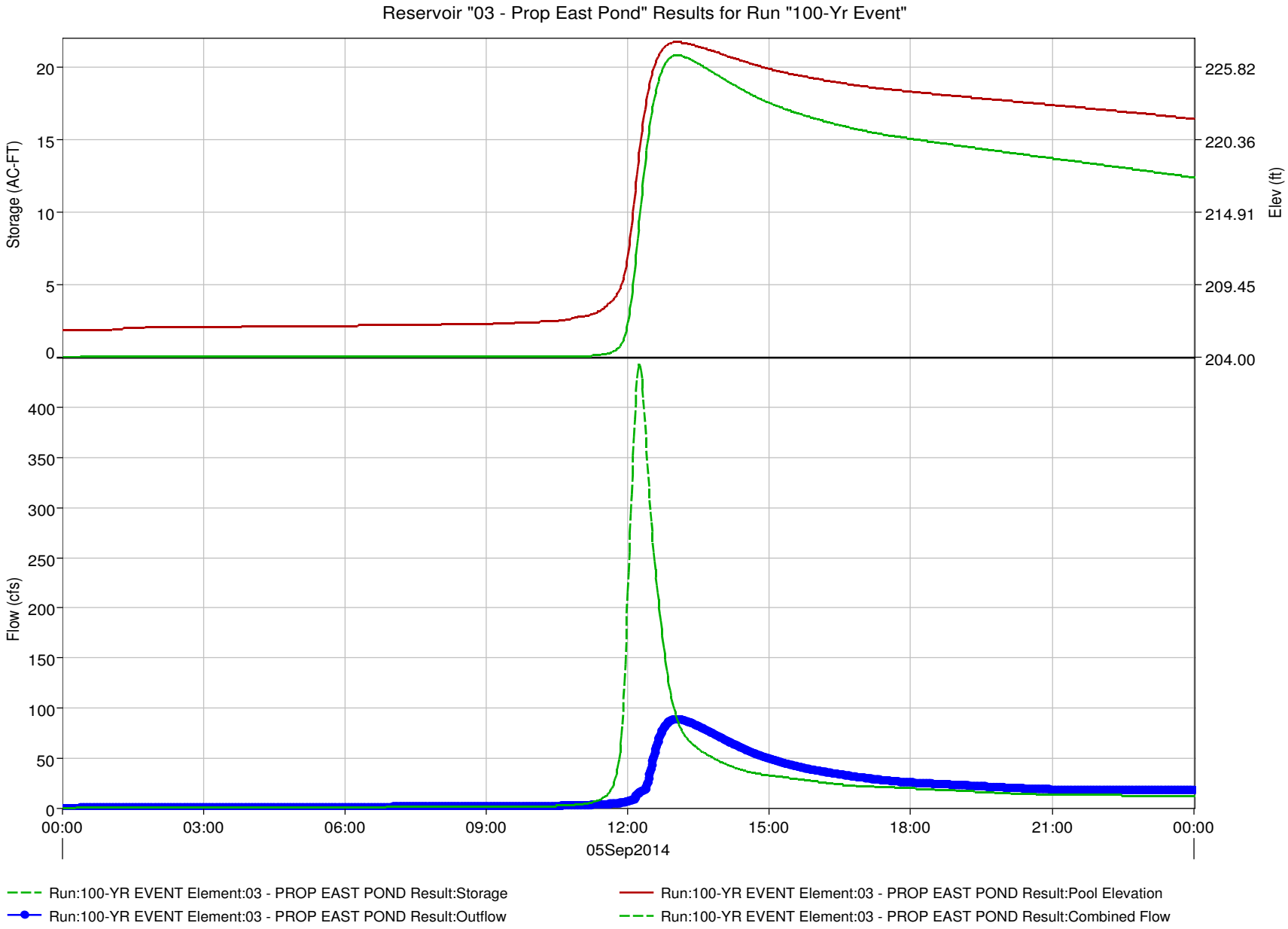
Post Closure Model Inputs			East Pond								Canal Pond	
			Area [02]	Area 3a	Area 3b	Area 3c	Area 3d	Area 3e	Area 3f	Area 3g	Area 4a	Area 4b
Total Drainage Area (ac)			42.81	9.48	1.66	8.68	3.39	2.54	10.68	4.99	2.76	306.20
Land Coverage (ac)	Heavy Woods, CN =	55	36.01	7.35	0	2.08	0.5	0	0	0	0	125.98
	Brush, CN =	48	0	0	0	0	1.25	0.78	0	0	0.97	180.22
	Grass/Meadow, CN =	58	5.07	2.13	1.58	6.6	1.34	1.71	10.68	4.69	1.49	0
	Gravel/Impervious, CN =	91	1.31	0	0.08	0	0.3	0.05	0	0.3	0.3	0
	Exposed CCR, CN =	91	0	0	0	0	0	0	0	0	0	0
	Water Surface, CN =	98	0.42	0	0	0	0	0	0	0	0	0
Composit CN			57	56	60	57	57	56	58	60	58	51
Percent Impervious (%)			4%	0%	5%	0%	9%	2%	0%	6%	11%	0%
Lag Time (min)			15	4	8	4	5	8	19	10	1	44

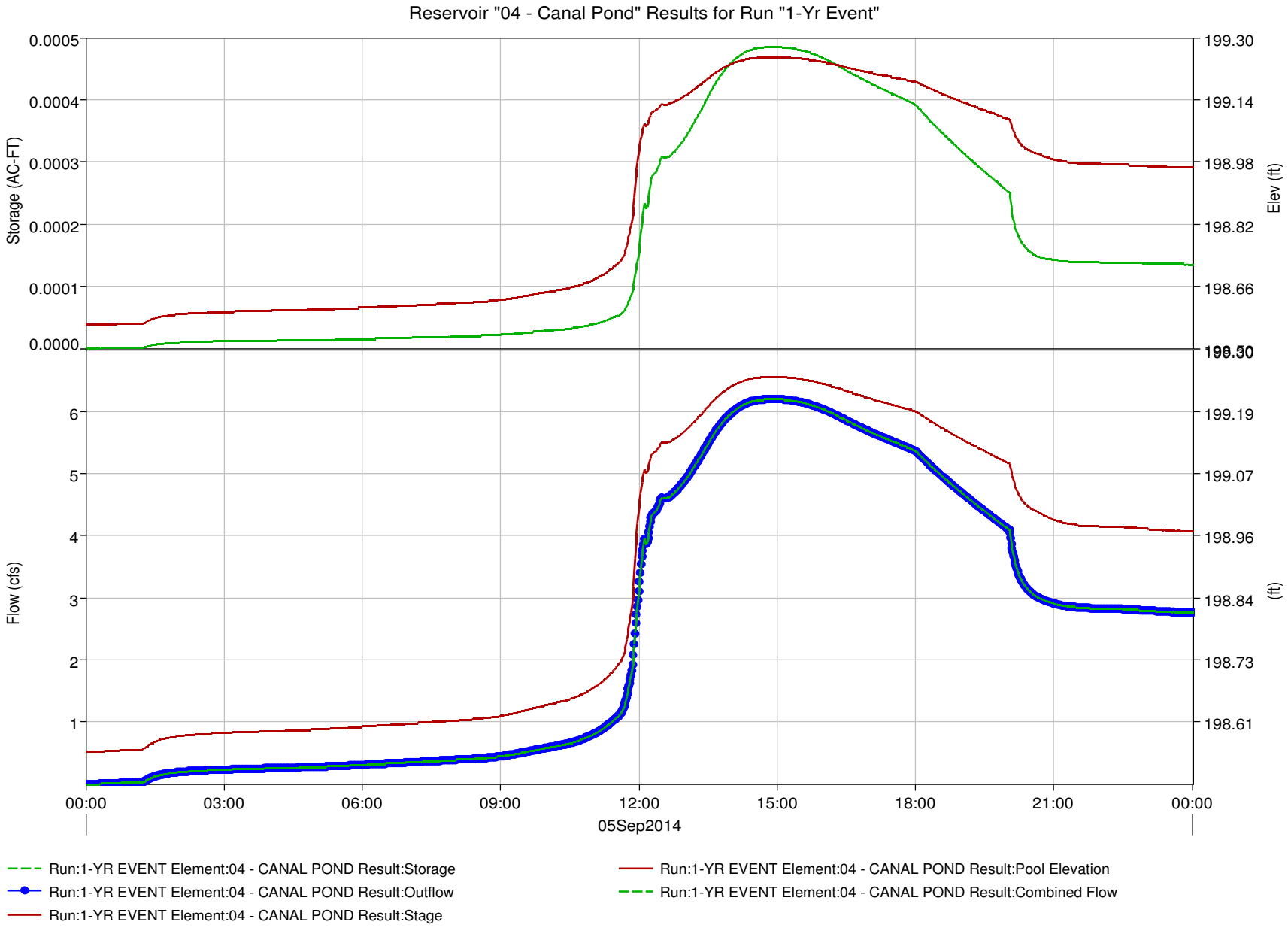
	Drainage Area	Peak Discharge (CFS)					
	DA (ac)	1-inch	1-year	2-year	10-year	25-year	100-year
Area [02]	42.88	5.60	15.30	22.40	57.10	87.50	149.10
02 - Pond	42.88	3.00	10.90	16.10	56.50	86.70	147.60
Area 3e	2.56	0.10	0.20	0.60	3.00	5.20	9.90
Reach-3e	45.44	3.00	11.00	16.30	58.20	89.70	153.50
NP Out A	103.04	0.00	3.40	14.30	82.40	141.90	250.40
NP Out B	103.04	0.00	3.40	14.30	82.40	141.90	250.40
Area 3d	3.20	0.40	1.00	1.80	5.70	9.10	15.90
Reach-3d	151.68	3.10	11.70	29.40	134.10	225.70	399.10
Area 3f	10.88	0.00	0.50	1.70	8.50	14.90	28.30
Area 3c	8.96	0.00	0.60	2.70	13.20	22.50	41.90
Reach-3cb	171.52	3.10	12.50	31.40	144.80	244.40	433.60
Area 3b	1.92	0.10	0.50	1.00	3.20	5.10	8.90
Reach-3ca	173.44	3.10	12.60	31.60	145.60	245.80	436.20
Area 3a	9.60	0.00	0.40	2.40	13.10	22.80	43.10
03 - Prop East Pond	183.04	2.70	4.70	6.08	13.35	18.60	88.60
03 - EP Spillway	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Area 3g	5.12	0.30	1.30	2.50	8.00	12.60	21.90
EP Cuvlert	5.12	0.30	1.10	2.10	5.80	8.50	13.70
Area [04a]	2.56	0.40	1.10	2.10	5.90	9.10	15.40
Reach-4a	7.68	0.50	1.50	2.70	8.00	12.60	20.60
Area [04b]	305.92	0.00	1.50	6.60	65.90	137.70	309.00
04 - Canal Pond	496.64	2.80	6.20	12.92	76.33	150.27	251.06
Outlet to James	496.64	2.80	6.20	12.90	76.30	150.30	251.10

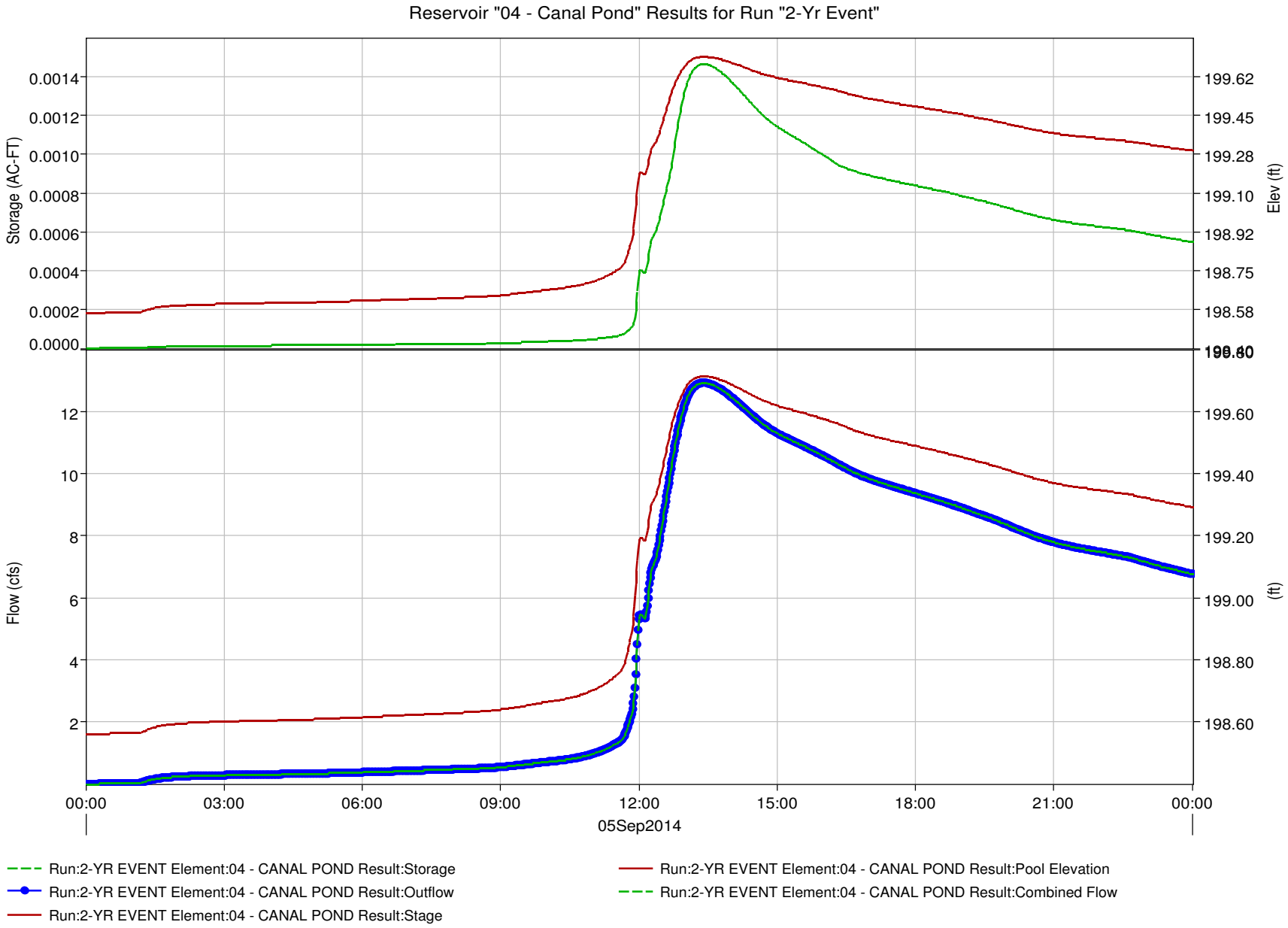

Reservoir "03 - Prop East Pond" Results for Run "1-Yr Event"
Storage (AC-FT)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Elev (ft)
209.50
208.93
208.36
207.79
207.21
206.64
206.07
205.50
Flow (cfs)
12
10
8
6
4
2
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:1-YR EVENT Element:03 - PROP EAST POND Result:Storage
Run:1-YR EVENT Element:03 - PROP EAST POND Result:Pool Elevation
Run:1-YR EVENT Element:03 - PROP EAST POND Result:Outflow
Run:1-YR EVENT Element:03 - PROP EAST POND Result:Combined Flow

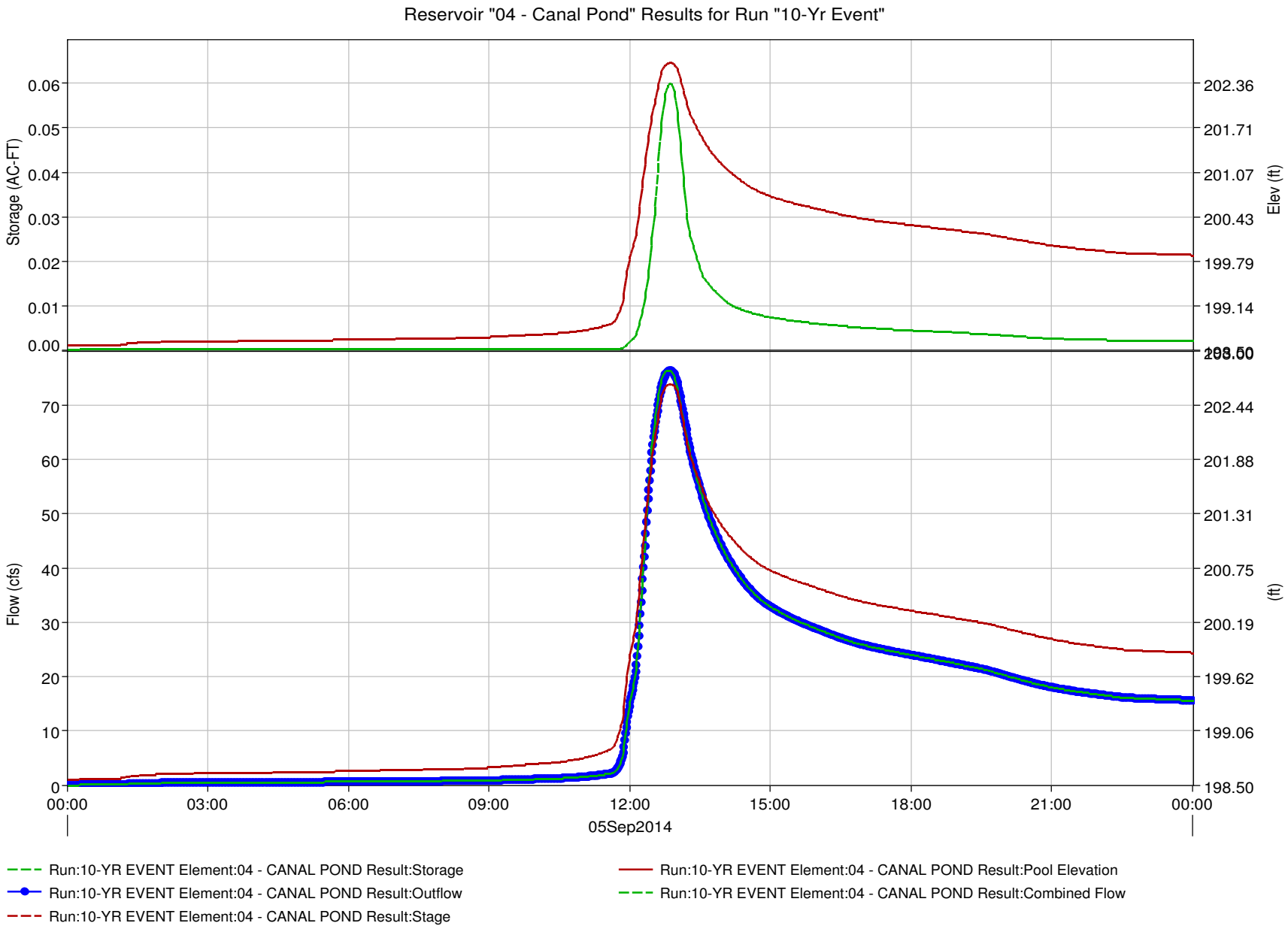

Reservoir "03 - Prop East Pond" Results for Run "2-Yr Event"
Storage (AC-FT)
Elev (ft)
Flow (cfs)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
212.00
211.30
210.60
209.90
209.20
208.50
207.80
207.10
206.40
205.70
205.00
30
25
20
15
10
5
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:2-YR EVENT Element:03 - PROP EAST POND Result:Storage
Run:2-YR EVENT Element:03 - PROP EAST POND Result:Pool Elevation
Run:2-YR EVENT Element:03 - PROP EAST POND Result:Outflow
Run:2-YR EVENT Element:03 - PROP EAST POND Result:Combined Flow

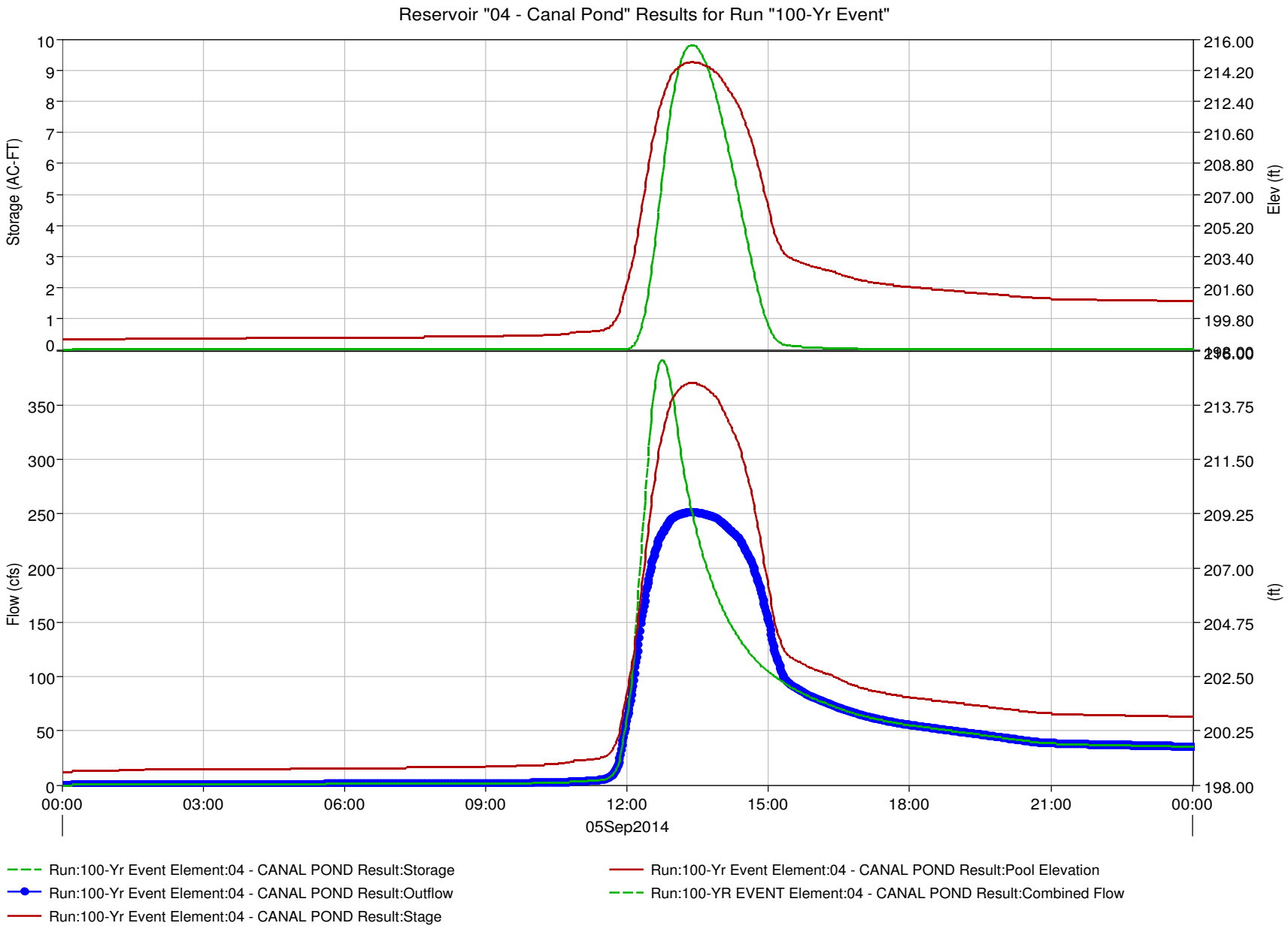

Reservoir "03 - Prop East Pond" Results for Run "10-Yr Event"
Storage (AC-FT)
Elev (ft)
Flow (cfs)
0
1
2
3
4
5
6
7
8
9
204.00
205.78
207.56
209.33
211.11
212.89
214.67
216.44
218.22
220.00
0
20
40
60
80
100
120
140
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:10-YR EVENT Element:03 - PROP EAST POND Result:Storage
Run:10-YR EVENT Element:03 - PROP EAST POND Result:Pool Elevation
Run:10-YR EVENT Element:03 - PROP EAST POND Result:Outflow
Run:10-YR EVENT Element:03 - PROP EAST POND Result:Combined Flow

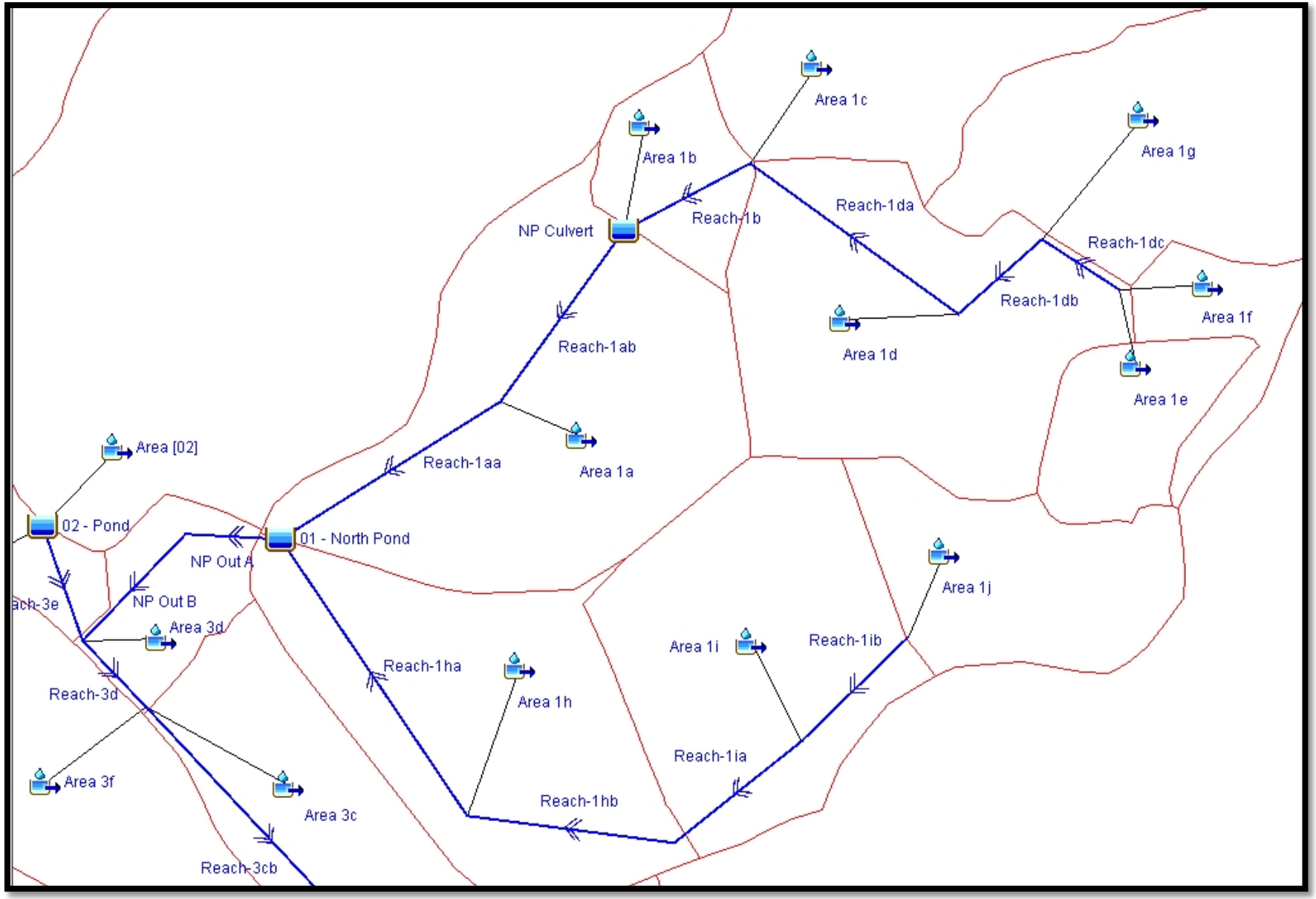

Reservoir "03 - Prop East Pond" Results for Run "100-Yr Event"
Storage (AC-FT)
Elev (ft)
20
15
10
5
0
225.82
220.36
214.91
209.45
204.00
Flow (cfs)
400
350
300
250
200
150
100
50
0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:100-YR EVENT Element:03 - PROP EAST POND Result:Storage
Run:100-YR EVENT Element:03 - PROP EAST POND Result:Pool Elevation
Run:100-YR EVENT Element:03 - PROP EAST POND Result:Outflow
Run:100-YR EVENT Element:03 - PROP EAST POND Result:Combined Flow


Reservoir "04 - Canal Pond" Results for Run "1-Yr Event"
Storage (AC-FT)
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
Elev (ft)
199.30
199.14
198.98
198.82
198.66
198.50
Flow (cfs)
6
5
4
3
2
1
(ft)
199.19
199.07
198.96
198.84
198.73
198.61
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:1-YR EVENT Element:04 - CANAL POND Result:Storage
Run:1-YR EVENT Element:04 - CANAL POND Result:Outflow
Run:1-YR EVENT Element:04 - CANAL POND Result:Stage
Run:1-YR EVENT Element:04 - CANAL POND Result:Pool Elevation
Run:1-YR EVENT Element:04 - CANAL POND Result:Combined Flow


Reservoir "04 - Canal Pond" Results for Run "2-Yr Event"
Storage (AC-FT)
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
Elev (ft)
199.62
199.45
199.28
199.10
198.92
198.75
198.58
Flow (cfs)
12
10
8
6
4
2
199.60
199.40
199.20
199.00
198.80
198.60
(ft)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:2-YR EVENT Element:04 - CANAL POND Result:Storage
Run:2-YR EVENT Element:04 - CANAL POND Result:Outflow
Run:2-YR EVENT Element:04 - CANAL POND Result:Stage
Run:2-YR EVENT Element:04 - CANAL POND Result:Pool Elevation
Run:2-YR EVENT Element:04 - CANAL POND Result:Combined Flow


Reservoir "04 - Canal Pond" Results for Run "10-Yr Event"
Storage (AC-FT)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Elev (ft)
202.36
201.71
201.07
200.43
199.79
199.14
Flow (cfs)
70
60
50
40
30
20
10
0
202.44
201.88
201.31
200.75
200.19
199.62
199.06
198.50
(ft)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:10-YR EVENT Element:04 - CANAL POND Result:Storage
Run:10-YR EVENT Element:04 - CANAL POND Result:Outflow
Run:10-YR EVENT Element:04 - CANAL POND Result:Stage
Run:10-YR EVENT Element:04 - CANAL POND Result:Pool Elevation
Run:10-YR EVENT Element:04 - CANAL POND Result:Combined Flow


Reservoir "04 - Canal Pond" Results for Run "100-Yr Event"
Storage (AC-FT)
Elev (ft)
Flow (cfs)
(ft)
0
1
2
3
4
5
6
7
8
9
10
198.00
199.80
201.60
203.40
205.20
207.00
208.80
210.60
212.40
214.20
216.00
0
50
100
150
200
250
300
350
198.00
200.25
202.50
204.75
207.00
209.25
211.50
213.75
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:100-Yr Event Element:04 - CANAL POND Result:Storage
Run:100-Yr Event Element:04 - CANAL POND Result:Outflow
Run:100-Yr Event Element:04 - CANAL POND Result:Stage
Run:100-Yr Event Element:04 - CANAL POND Result:Pool Elevation
Run:100-YR EVENT Element:04 - CANAL POND Result:Combined Flow

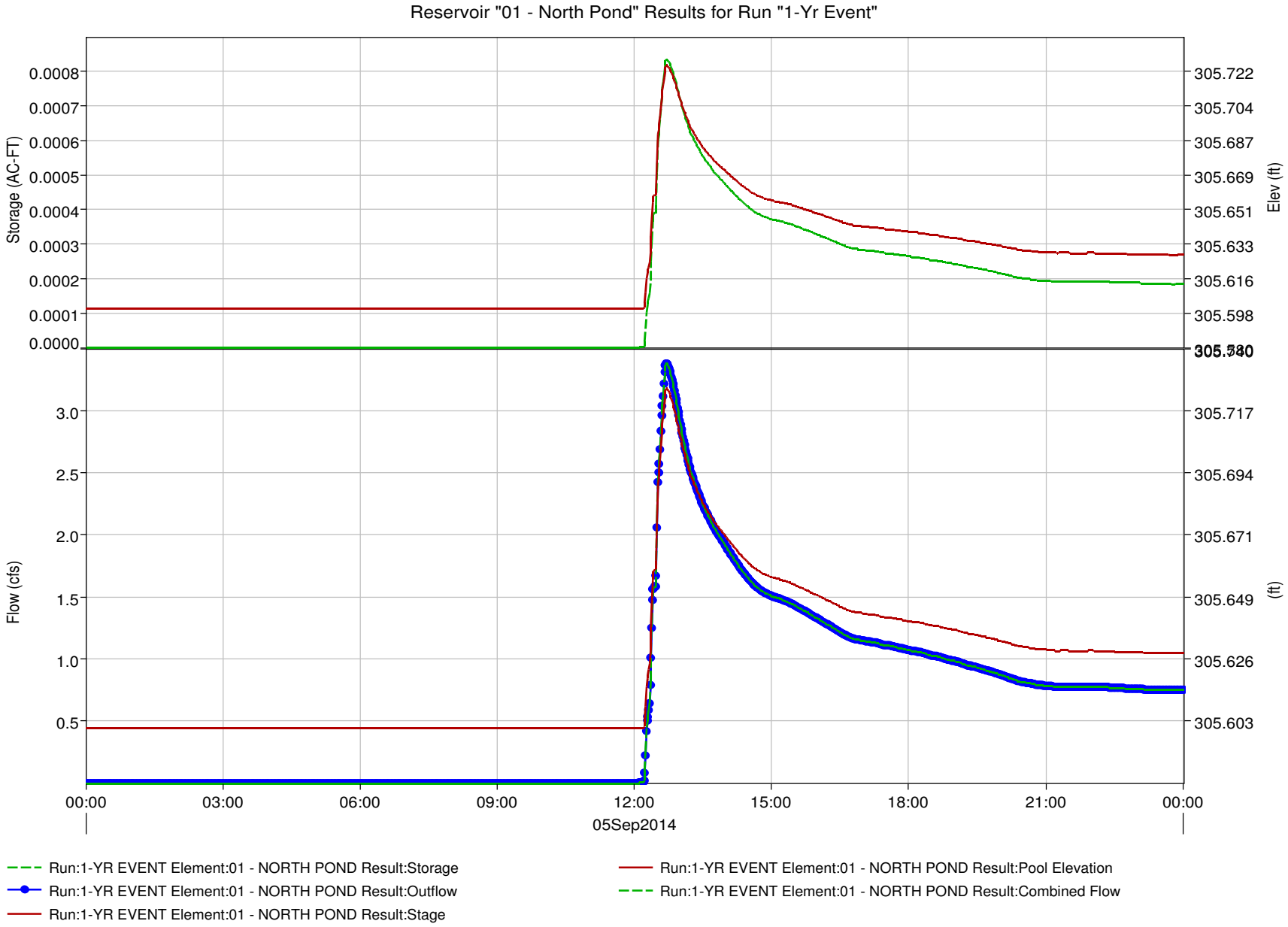


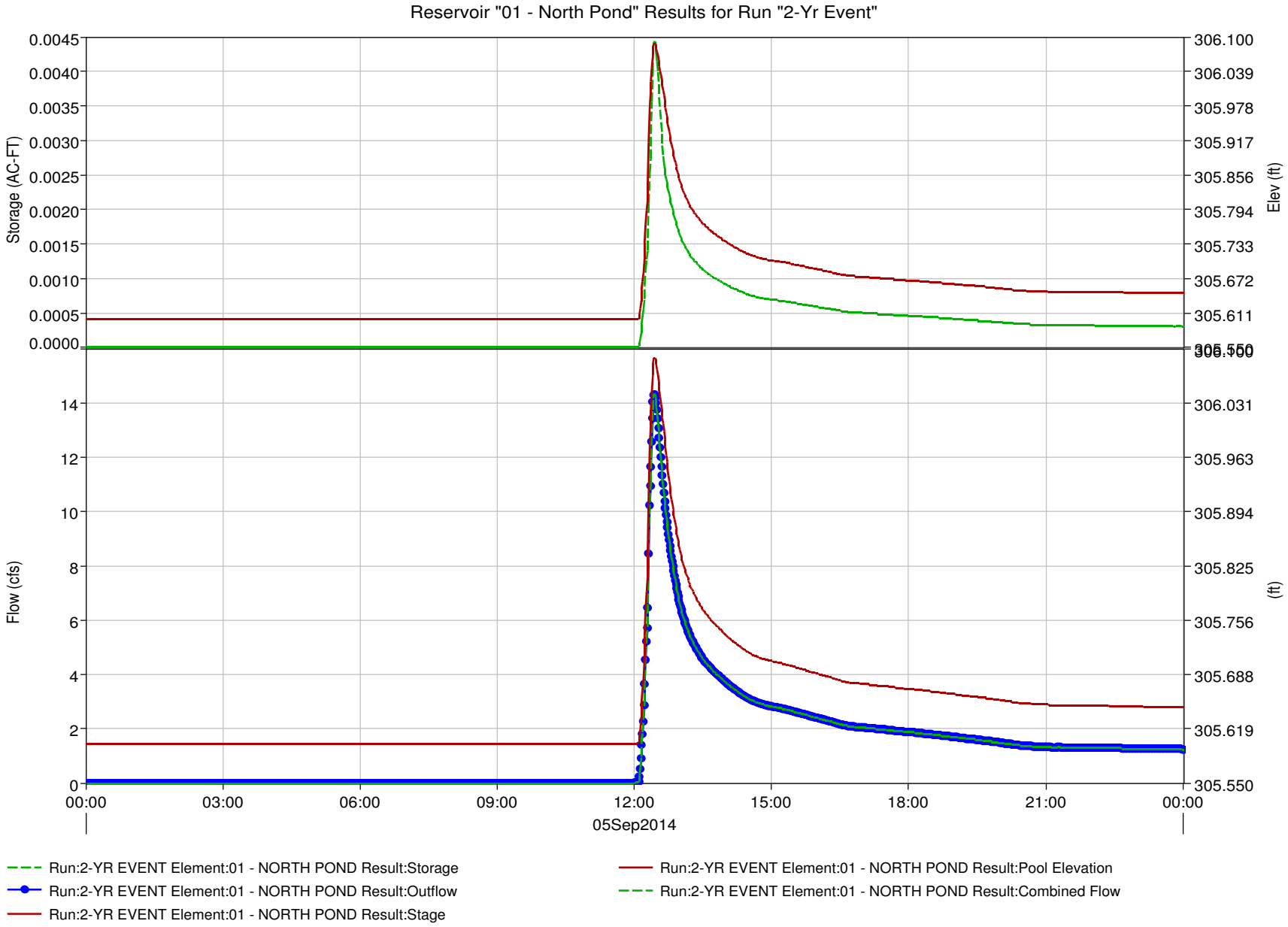
Model for North Pond - Proposed

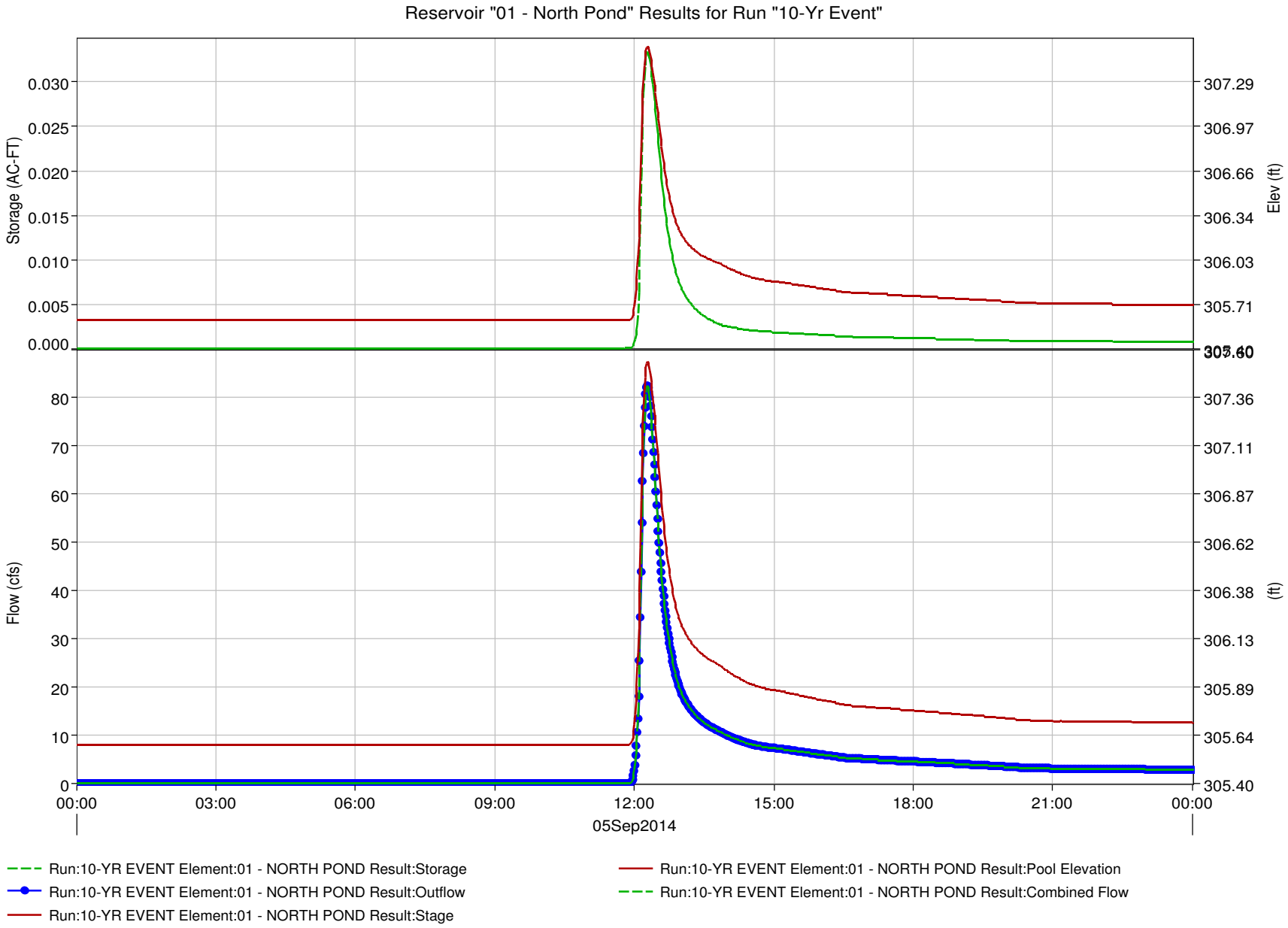
North Pond

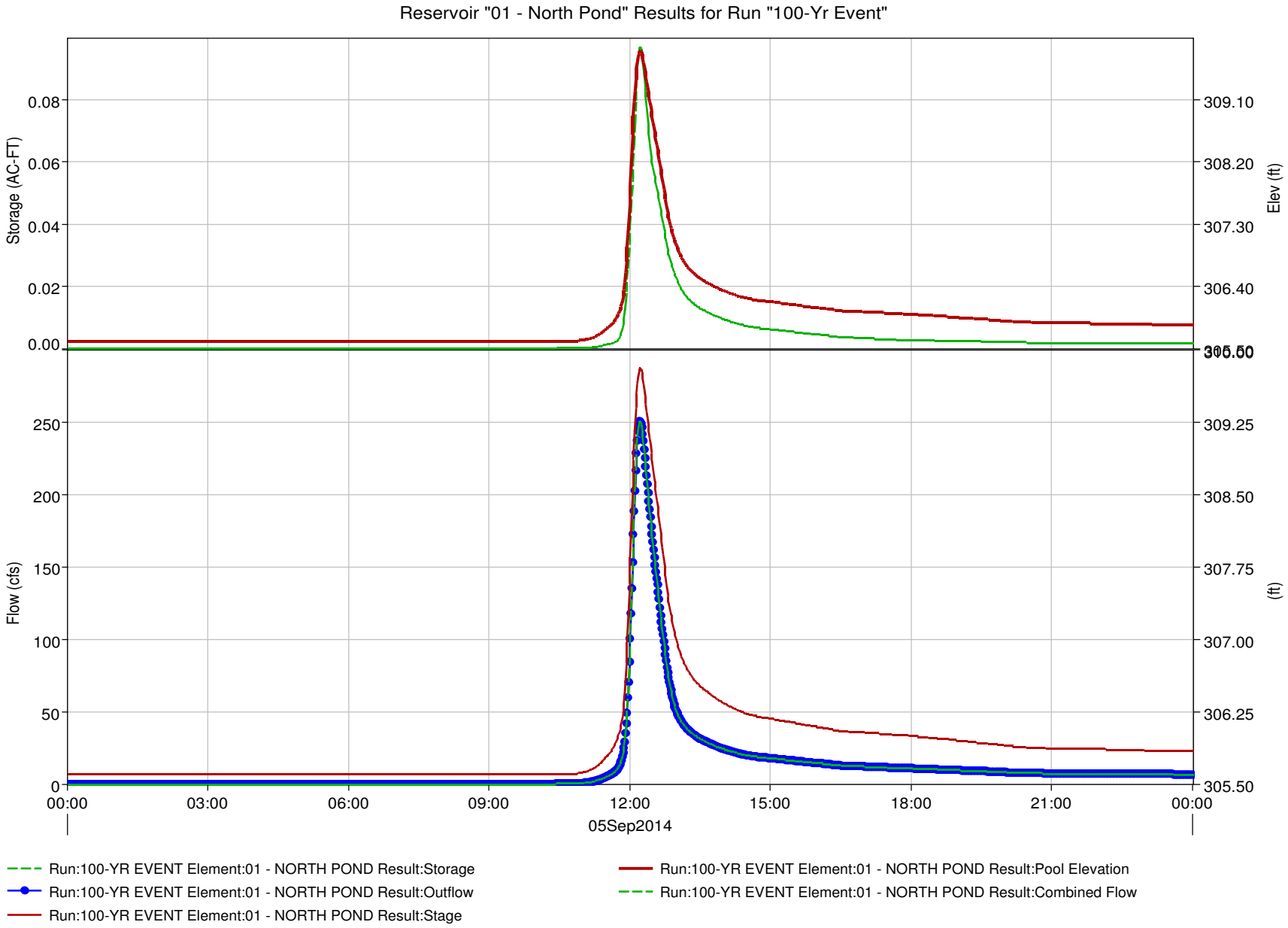
Post Closure Model Inputs			North Pond									
			Area 1a	Area 1b	Area 1c	Area 1d	Area 1e	Area 1f	Area 1g	Area 1h	Area 1i	Area 1j
Total Drainage Area (ac)			17.32	3.40	11.67	14.07	3.83	2.96	16.95	13.36	12.57	7.18
Land Coverage (ac)	Heavy Woods, CN =	55	0	0.27	5.63	3.48	0	0.64	12.89	0	0.75	2.63
	Brush, CN =	48	0	0	1.2	0	0	0	1.25	0	0	0
	Grass/Meadow, CN =	58	17.32	3.13	4.84	10.59	3.83	2.32	2.81	13.36	11.82	4.55
	Gravel/Impervious, CN =	91	0	0	0	0	0	0	0	0	0	0
	Exposed CCR, CN =	91	0	0	0	0	0	0	0	0	0	0
	Water Surface, CN =	98	0	0	0	0	0	0	0	0	0	0
Composit CN			58	58	56	57	58	57	55	58	58	57
Percent Impervious (%)			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Lag Time (min)			17	9	16	13	15	11	10	15	14	8

	Drainage Area	Peak Discharge (CFS)					
	DA (ac)	1-inch	1-year	2-year	10-year	25-year	100-year
Area 1e	3.84	0.00	0.20	0.70	3.50	6.20	11.60
Area 1f	3.20	0.00	0.10	0.60	3.30	5.80	11.00
Reach-1dc	7.04	0.00	0.30	1.20	6.60	11.60	22.00
Area 1g	16.64	0.00	0.30	2.10	15.10	27.80	54.70
Reach-1db	23.68	0.00	0.60	3.20	21.20	38.50	75.40
Area 1d	14.08	0.00	0.50	2.30	13.10	23.20	44.20
Reach-1da	37.76	0.00	1.00	5.40	34.20	61.60	119.20
Area 1c	11.52	0.00	0.30	1.30	8.50	15.60	30.70
Reach-1b	49.28	0.00	1.30	6.70	42.50	76.90	149.30
Area 1b	3.20	0.00	0.20	0.80	3.90	6.70	12.50
NP Culvert	52.48	0.00	1.40	6.80	40.20	68.20	110.70
Reach-1ab	52.48	0.00	1.40	6.70	40.10	68.20	110.70
Area 1a	17.28	0.00	0.80	2.90	14.60	25.60	48.20
Reach-1aa	69.76	0.00	2.10	9.20	53.50	91.40	154.20
Area 1j	7.04	0.00	0.30	1.60	8.40	14.70	27.60
Reach-1ib	7.04	0.00	0.30	1.60	8.40	14.60	27.50
Area 1i	12.80	0.00	0.60	2.40	12.30	21.40	40.20
Reach-1ia	19.84	0.00	0.90	3.80	19.80	34.40	64.70
Reach-1hb	19.84	0.00	0.90	3.80	19.70	34.20	64.40
Area 1h	13.44	0.00	0.60	2.40	12.40	21.50	40.50
Reach-1ha	33.28	0.00	1.50	6.00	31.70	55.40	104.60
01 - North Pond	103.04	0.00	3.40	14.30	82.50	142.10	250.50


Reservoir "01 - North Pond" Results for Run "1-Yr Event"
Storage (AC-FT)
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
Elev (ft)
305.722
305.704
305.687
305.669
305.651
305.633
305.616
305.598
305.580
Flow (cfs)
3.0
2.5
2.0
1.5
1.0
0.5
(ft)
305.717
305.694
305.671
305.649
305.626
305.603
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:1-YR EVENT Element:01 - NORTH POND Result:Storage
Run:1-YR EVENT Element:01 - NORTH POND Result:Outflow
Run:1-YR EVENT Element:01 - NORTH POND Result:Stage
Run:1-YR EVENT Element:01 - NORTH POND Result:Pool Elevation
Run:1-YR EVENT Element:01 - NORTH POND Result:Combined Flow


Reservoir "01 - North Pond" Results for Run "2-Yr Event"
Storage (AC-FT)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Elev (ft)
306.100
306.039
305.978
305.917
305.856
305.794
305.733
305.672
305.611
305.550
Flow (cfs)
14
12
10
8
6
4
2
0
306.031
305.963
305.894
305.825
305.756
305.688
305.619
305.550
(ft)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:2-YR EVENT Element:01 - NORTH POND Result:Storage
Run:2-YR EVENT Element:01 - NORTH POND Result:Outflow
Run:2-YR EVENT Element:01 - NORTH POND Result:Stage
Run:2-YR EVENT Element:01 - NORTH POND Result:Pool Elevation
Run:2-YR EVENT Element:01 - NORTH POND Result:Combined Flow


Reservoir "01 - North Pond" Results for Run "10-Yr Event"
Storage (AC-FT)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Elev (ft)
307.29
306.97
306.66
306.34
306.03
305.71
305.40
Flow (cfs)
80
70
60
50
40
30
20
10
0
307.36
307.11
306.87
306.62
306.38
306.13
305.89
305.64
305.40
(ft)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:10-YR EVENT Element:01 - NORTH POND Result:Storage
Run:10-YR EVENT Element:01 - NORTH POND Result:Outflow
Run:10-YR EVENT Element:01 - NORTH POND Result:Stage
Run:10-YR EVENT Element:01 - NORTH POND Result:Pool Elevation
Run:10-YR EVENT Element:01 - NORTH POND Result:Combined Flow


Reservoir "01 - North Pond" Results for Run "100-Yr Event"
Storage (AC-FT)
0.08
0.06
0.04
0.02
0.00
Elev (ft)
309.10
308.20
307.30
306.40
305.50
Flow (cfs)
250
200
150
100
50
0
309.25
308.50
307.75
307.00
306.25
305.50
(ft)
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
05Sep2014
Run:100-YR EVENT Element:01 - NORTH POND Result:Storage
Run:100-YR EVENT Element:01 - NORTH POND Result:Outflow
Run:100-YR EVENT Element:01 - NORTH POND Result:Stage
Run:100-YR EVENT Element:01 - NORTH POND Result:Pool Elevation
Run:100-YR EVENT Element:01 - NORTH POND Result:Combined Flow

Appendix G

Closure Cost Estimate

Worksheet CEW-01: FORMAT FOR THE ESTIMATION OF CLOSURE COSTS

Facility Name: Bremo Power Station
Permit Number: North Ash Pond
Facility Address: 1038 Bremo Bluff Road
Bremo Bluff, Virginia 23022
Facility Owner: Virginia Electric and Power Company
Owner Representative: David Craymer
Representative Completing Format: Golder Associates Inc., Ron DiFrancesco, P.E.
Date Completed: December 1, 2015

Total Permitted Footprint	67.5	ac.	
Developed Ash Pond Area (To be Closed)	**67.5**	**ac.**	**Requires Full Cap Section**
Remaining Undeveloped Area	0	ac.	

Soil Cap Components

I. Slope & Fill

				Calculation or Conversion		
a.	Area to be capped	67.5	acres	x 4,840yd2/ac	326,700	yd2
b.	Depth of soil needed for slope and fill	0	inches	x 1yd/36in	0.00	yd
c.	Quantity of soil needed			a x b	0	yd3
d.	Percentage of soil from off-site	0%				
e.	Purchase unit cost for off-site material	$0.00	/yd3			
f.	Percentage of soil from on-site	0		(1 - d)	100%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3		0	
h.	Total soil unit cost			(d x e) + (f x g)	$0.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3		0	
j.	Compaction unit cost	$0.00	/yd3			
k.	Total soil unit cost			h + i + j	$0.00	/yd3
l.	Soil subtotal			k x b	$0	
m.	Percent compaction	20%				
	Total Slope & Fill Cost			l x (1 + m)	***$0***	

II. Erosion Control / Protective Cover Soil

a.	Area to be capped	67.5	acres	x 4,840yd2/ac	326,700	yd2
b.	Depth of soil needed	18	inches	x 1yd/36in	0.50	yd
c.	Quantity of soil needed			a x b	163,350	yd3
d.	Percentage of soil from off-site	100%				
e.	Purchase unit cost for off-site material	$11.65	/yd3			
f.	Percentage of soil from on-site	0		(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total erosion/protective soil unit cost			(d x e) + (f x g)	$11.65	/yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3			
j.	Compaction unit cost	$0.00	/yd3			
k.	Total soil unit cost			h + i + j	$16.55	/yd3
l.	Erosion/Protective soil subtotal			k x b	$2,703,443	
m.	Percent compaction	20%				
	Total Erosion Control/Protective Cover Soil Cost			l x (1 + m)	***$3,244,131***	

III. Vegetative support soil (Topsoil)

a.	Area to be capped	67.5	acres	x 4,840yd2/ac	326,700	yd2
b.	Depth of topsoil needed	6	inches	x 1yd/36in	0.17	yd
c.	Quantity of topsoil needed			a x b	54,450	yd3
d.	Percentage of topsoil from off-site	100%				
e.	Purchase unit cost for off-site material	$11.65	/yd3			
f.	Percentage of topsoil from on-site	0		(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total topsoil unit cost			(d x e) + (f x g)	$11.65	/yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3			
j.	Total soil unit cost			h + i	$16.55	/yd3
	Total Topsoil Cost			c x j	***$901,148***	

IV. Vegetative Cover

a.	Area to be vegetated	67.5	acres			
b.	Vegetative cover (seeding) unit cost	$2,350	/acre			
b.	Erosion Control Matting Quantity	70,000	yd2			
c.	Erosion control matting unit cost	$4.40	/yd2			
	Total Vegetative Cover Cost			a x (b + c)	***$466,625***	

Soil Cap Component Subtotal: $4,611,904

Geosynthetic Barrier & Infiltration Layers

V. Flexible Membrane Liner

				Calculation or Conversion		
a.	Quantity of FML needed	67.5	acres	x 43,560ft2/ac	2,940,300	ft2
b.	Purchase unit cost	$0.24	/ft2			
c.	Installation unit cost	$0.16	/ft2			
d.	Total FML unit cost			b + c	$0.40	
	Total FML cost			a x d	***$1,173,180***	

VI. Geosynthetic Clay Liner

a.	Quantity of GCL needed	0	acres	x 43,560ft2/ac	0	ft2
b.	Purchase unit cost	$0.00	/ft2			
c.	Installation unit cost	$0.00	/ft2			
d.	Total GCL unit cost			b + c	$0.00	/ft2
	Total GCL Cost			a x d	***$0***	

Geosynthetic Layers Subtotal: $1,173,180

Drainage Components

VII. Sand or Gravel Drainage

				Calculation or Conversion		
a.	Area to be capped	0	acres	x 4,840yd2/ac	0	yd2
b.	Depth of sand or gravel needed	0	inches	x 1yd/36in	0.00	yd
c.	Quantity of drainage material needed			a x b	0	yd3
d.	Percentage of media from off-site	0%				
e.	Purchase unit cost for off-site material	$0.00	/yd3			
f.	Percentage of material from on-site			(1 - d)	100%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total drainage material unit cost			(d x e) + (f x g)	$0.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3			
j.	Compaction unit cost	$0.00	/yd3			
k.	Total drainage material unit cost			h + i + j	$0.00	/yd3
l.	Drainage material subtotal			k x b	$0.00	
m.	Percent compaction	0%				
	Total drainage material cost			l x (1 + m)	***$0***	

VIII. Geotextile

a.	Quantity of geotextile needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.00	/ft2		
c.	Installation unit cost	$0.00	/ft2		
d.	Total geotextile unit cost			b + c	$0.000 /ft2
	Total Geotextile Cost			a x d	***$0***

IX. Geonet Composite

a.	Quantity of geonet composite needed	67.5	acres	x 43,560ft2/ac	2,940,300 ft2
b.	Purchase unit cost	$0.39	/ft2		
c.	Installation unit cost	$0.19	/ft2		
d.	Total geonet composite unit cost			b + c	$0.58 /ft2
	Total Geonet Composite Cost			a x d	***$1,699,493***

X. Cap Underdrain System

a.	Length of Cap Underdrain needed	8,700	LF
a.	Length of Channel Underdrain needed	5,600	LF
b.	Purchase unit cost (Cap Underdrain)	$28.15	/LF
c.	Purchase unit cost (Channel Underdrain)	$46.75	/LF
	Total Underdrain Cost		a x d ***$506,705***

XI. Stormwater Controls

Rip Rap

g.	Quantity of Rip Rap needed	10000	ton		
h.	Rip rap unit cost	$55.30	/ton		
i.	*Total rip rap cost*			g x h	*$553,000*

Additional Stormwater Controls

k.	Additional Stormwater Controls	$720,000.00			
	Total Stormwater Control			c + f + i + l	***$1,273,000***

Drainage Component Subtotal: $3,479,198

Miscellaneous

				Calculation		
XII.	**Removal and Disposal of Stockpiled Material**					
a.	Quantity of stockpiled CCR	-	ton			
b.	Loading and Hauling unit cost	$76.25	/ton			
c.	Disposal unit cost	$0.00	/ton			
d.	***Total Removal/Disposal Cost***			a x (b + c)	***$0***	
XIII.	**Erosion/Sediment Control**					
a.	Quantity of silt fence needed	1,800	LF			
b.	Silt Fence unit cost	$2.05	/LF			
	Total Silt Fence Cost			a x b	***$3,690***	
XIV.	**Site Security**					
Fencing						
a.	Length of fencing needed	-	ft			
b.	Fence unit cost	$0.00	/ft			
c.	*Subtotal fencing cost*			a x b	*$0*	
Gate or Barrier						
d.	Number of gates required	-				
e.	Gate unit cost	$0.00	/gate			
f.	*Subtotal gate cost*			d x e	*$0*	
Closed Sign						
g.	Number of signs required	-				
h.	Sign unit cost	$0.00	/sign			
i.	*Subtotal sign cost*			g x h	*$0*	
	Total site security cost			c + f + i	***$0***	
XV.	**Mobilization / Demobilization**					
a.	Cost for mobilization/demobilization	$170,000				
	Total mobilization/demobilization cost				***$170,000***	
					Miscellaneous Subtotal:	**$173,690**

Closure Cost Subtotal (CCS):	(I + … + XIX)	$9,437,972	
Contingency (8%):	CCS x 0.08	$755,038	
Engineering & Documentation:			
Construction QA/QC (10%)	CCS x 0.10	$943,797	
Closure Certification and CQA Report (1%)	included above	n/a	
Survey and as-builts (2%)	included above	n/a	
Construction Documents (1%)	CCS x 0.01	$94,380	
Cost for survey and deed notation		$7,500	
Total Engineering & Documentation Costs		***$1,045,677***	
Total Closure Cost:	CCS + Contingency + Engineering		**$11,238,686**
	Per acre closure cost estimate		**$166,499.05**

Worksheet CEW-01: FORMAT FOR THE ESTIMATION OF CLOSURE COSTS

Facility Name: Bremo Power Station
Permit Number: East Ash Pond
Facility Address: 1038 Bremo Bluff Road
Bremo Bluff, Virginia 23022
Facility Owner: Virginia Electric and Power Company
Owner Representative: David Craymer
Representative Completing Format: Golder Associates Inc., Ron DiFrancesco, P.E.
Date Completed: December 1, 2015

Total Permitted Footprint	27.4	ac.	
Developed Ash Pond Area (To be Closed)	**27.4**	**ac.**	**Requires Full Cap Section**
Remaining Undeveloped Area	0	ac.	

Soil Cap Components

					Calculation or Conversion		
I.	**Slope & Fill**						
a.	Area to be capped	27.4	acres		x 4,840yd2/ac	132,616	yd2
b.	Depth of soil needed for slope and fill	0	inches		x 1yd/36in	0.00	yd
c.	Quantity of soil needed				a x b	0	yd3
d.	Percentage of soil from off-site	0%					
e.	Purchase unit cost for off-site material	$0.00	/yd3				
f.	Percentage of soil from on-site	0			(1 - d)	100%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			0	
h.	Total soil unit cost				(d x e) + (f x g)	$0.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3			0	
j.	Compaction unit cost	$0.00	/yd3				
k.	Total soil unit cost				h + i + j	$0.00	/yd3
l.	Soil subtotal				k x b	$0	
m.	Percent compaction	20%					
	Total Slope & Fill Cost				l x (1 + m)	***$0***	
II.	**Erosion Control / Protective Cover Soil**						
a.	Area to be capped	27.4	acres		x 4,840yd2/ac	132,616	yd2
b.	Depth of soil needed	18	inches		x 1yd/36in	0.50	yd
c.	Quantity of soil needed				a x b	66,308	yd3
d.	Percentage of soil from off-site	100%					
e.	Purchase unit cost for off-site material	$11.65	/yd3				
f.	Percentage of soil from on-site	0			(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3				
h.	Total erosion/protective soil unit cost				(d x e) + (f x g)	$11.65	/yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3				
j.	Compaction unit cost	$0.00	/yd3				
k.	Total soil unit cost				h + i + j	$16.55	/yd3
l.	Erosion/Protective soil subtotal				k x b	$1,097,397	
m.	Percent compaction	20%					
	Total Erosion Control/Protective Cover Soil Cost				l x (1 + m)	***$1,316,877***	

III. Vegetative support soil (Topsoil)

a.	Area to be capped	27.4	acres	x 4,840yd2/ac	132,616	yd2
b.	Depth of topsoil needed	6	inches	x 1yd/36in	0.17	yd
c.	Quantity of topsoil needed			a x b	22,103	yd3
d.	Percentage of topsoil from off-site	100%				
e.	Purchase unit cost for off-site material	$11.65	/yd3			
f.	Percentage of topsoil from on-site	0		(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total topsoil unit cost			(d x e) + (f x g)	$11.65	/yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3			
j.	Total soil unit cost			h + i	$16.55	/yd3
	Total Topsoil Cost			c x j	***$365,799***	

IV. Vegetative Cover

a.	Area to be vegetated	27.4	acres			
b.	Vegetative cover (seeding) unit cost	$2,350	/acre			
b.	Erosion Control Matting Quantity	50,000	yd2			
c.	Erosion control matting unit cost	$4.40	/yd2			
	Total Vegetative Cover Cost			a x (b + c)	***$284,390***	

Soil Cap Component Subtotal: $1,967,066

Geosynthetic Barrier & Infiltration Layers

V. Flexible Membrane Liner

				Calculation or Conversion		
a.	Quantity of FML needed	27.4	acres	x 43,560ft2/ac	1,193,544	ft2
b.	Purchase unit cost	$0.24	/ft2			
c.	Installation unit cost	$0.16	/ft2			
d.	Total FML unit cost			b + c	$0.40	
	Total FML cost			a x d	***$476,224***	

VI. Geosynthetic Clay Liner

a.	Quantity of GCL needed	0	acres	x 43,560ft2/ac	0	ft2
b.	Purchase unit cost	$0.00	/ft2			
c.	Installation unit cost	$0.00	/ft2			
d.	Total GCL unit cost			b + c	$0.00	/ft2
	Total GCL Cost			a x d	***$0***	

Geosynthetic Layers Subtotal: $476,224

Drainage Components

VII. Sand or Gravel Drainage

				Calculation or Conversion		
a.	Area to be capped	0	acres	x 4,840yd2/ac	0	yd2
b.	Depth of sand or gravel needed	0	inches	x 1yd/36in	0.00	yd
c.	Quantity of drainage material needed			a x b	0	yd3
d.	Percentage of media from off-site	0%				
e.	Purchase unit cost for off-site material	$0.00	/yd3			
f.	Percentage of material from on-site			(1 - d)	100%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			
h.	Total drainage material unit cost			(d x e) + (f x g)	$0.00	/yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3			
j.	Compaction unit cost	$0.00	/yd3			
k.	Total drainage material unit cost			h + i + j	$0.00	/yd3
l.	Drainage material subtotal			k x b	$0.00	
m.	Percent compaction	0%				
	Total drainage material cost			l x (1 + m)	***$0***	

VIII. Geotextile

a.	Quantity of geotextile needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.00	/ft2		
c.	Installation unit cost	$0.00	/ft2		
d.	Total geotextile unit cost			b + c	$0.000 /ft2
	Total Geotextile Cost			a x d	***$0***

IX. Geonet Composite

a.	Quantity of geonet composite needed	27.4	acres	x 43,560ft2/ac	1,193,544 ft2
b.	Purchase unit cost	$0.39	/ft2		
c.	Installation unit cost	$0.19	/ft2		
d.	Total geonet composite unit cost			b + c	$0.58 /ft2
	Total Geonet Composite Cost			a x d	***$689,868***

X. Cap Underdrain System

a.	Length of Cap Underdrain needed	4,000	LF
a.	Length of Channel Underdrain needed	5,000	LF
b.	Purchase unit cost (Cap Underdrain)	$28.15	/LF
c.	Purchase unit cost (Channel Underdrain)	$46.75	/LF
	Total Underdrain Cost		a x d ***$346,350***

XI. Stormwater Controls

Rip Rap

g.	Quantity of Rip Rap needed	3000	ton
h.	Rip rap unit cost	$55.30	/ton
i.	*Total rip rap cost*		g x h *$165,900*

Additional Stormwater Controls

k.	Additional Stormwater Controls	$80,000.00

Total Stormwater Control c + f + i + l ***$245,900***

Drainage Component Subtotal: $1,282,118

Miscellaneous

				Calculation	
XII.	**Removal and Disposal of Stockpiled Material**				
a.	Quantity of stockpiled CCR	-	ton		
b.	Loading and Hauling unit cost	$76.25	/ton		
c.	Disposal unit cost	$0.00	/ton		
d.	***Total Removal/Disposal Cost***			a x (b + c)	***$0***
XIII.	**Erosion/Sediment Control**				
a.	Quantity of silt fence needed	5,000	LF		
b.	Silt Fence unit cost	$2.05	/LF		
	Total Silt Fence Cost			a x b	***$10,250***
XIV.	**Site Security**				
Fencing					
a.	Length of fencing needed	-	ft		
b.	Fence unit cost	$0.00	/ft		
c.	*Subtotal fencing cost*			a x b	*$0*
Gate or Barrier					
d.	Number of gates required	-			
e.	Gate unit cost	$0.00	/gate		
f.	*Subtotal gate cost*			d x e	*$0*
Closed Sign					
g.	Number of signs required	-			
h.	Sign unit cost	$0.00	/sign		
i.	*Subtotal sign cost*			g x h	*$0*
	Total site security cost			c + f + i	***$0***
XV.	**Mobilization / Demobilization**				
a.	Cost for mobilization/demobilization	$380,000			
	Total mobilization/demobilization cost				***$380,000***

Miscellaneous Subtotal: **$390,250**

Closure Cost Subtotal (CCS):	(I + … + XIX)	$4,115,659	
Contingency (8%):	CCS x 0.08	$329,253	
Engineering & Documentation:			
Construction QA/QC (10%)	CCS x 0.10	$411,566	
Closure Certification and CQA Report (1%)	included above	n/a	
Survey and as-builts (2%)	included above	n/a	
Construction Documents (1%)	CCS x 0.01	$41,157	
Cost for survey and deed notation		$7,500	
Total Engineering & Documentation Costs		***$460,222***	
Total Closure Cost:	CCS + Contingency + Engineering		**$4,905,134**
	Per acre closure cost estimate		**$179,019.48**

Worksheet CEW-01: FORMAT FOR THE ESTIMATION OF CLOSURE COSTS

Facility Name: Bremo Power Station
Permit Number: West Ash Pond
Facility Address: 1038 Bremo Bluff Road
Bremo Bluff, Virginia 23022
Facility Owner: Virginia Electric and Power Company
Owner Representative: David Craymer
Representative Completing Format: Golder Associates Inc., Ron DiFrancesco, P.E.
Date Completed: December 1, 2015

Total Permitted Footprint	21.5	ac.	
Developed Ash Pond Area (To be Closed)	**21.5**	**ac.**	**Requires Full Cap Section**
Remaining Undeveloped Area	0	ac.	

Soil Cap Components

					Calculation or Conversion		
I.	**Slope & Fill**						
a.	Area to be capped	21.5	acres		x 4,840yd2/ac	104,060	yd2
b.	Depth of soil needed for slope and fill	28	inches		x 1yd/36in	0.78	yd
c.	Quantity of soil needed				a x b	80,936	yd3
d.	Percentage of soil from off-site	100%					
e.	Purchase unit cost for off-site material	$11.65	/yd3				
f.	Percentage of soil from on-site	0			(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3			0	
h.	Total soil unit cost				(d x e) + (f x g)	$11.65	/yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3			0	
j.	Compaction unit cost	$0.00	/yd3				
k.	Total soil unit cost				h + i + j	$16.55	/yd3
l.	Soil subtotal				k x b	$1,339,483	
m.	Percent compaction	20%					
	Total Slope & Fill Cost				l x (1 + m)	***$1,607,380***	
II.	**Erosion Control / Protective Cover Soil**						
a.	Area to be capped	0	acres		x 4,840yd2/ac	0	yd2
b.	Depth of soil needed	0	inches		x 1yd/36in	0.00	yd
c.	Quantity of soil needed				a x b	0	yd3
d.	Percentage of soil from off-site	100%					
e.	Purchase unit cost for off-site material	$11.65	/yd3				
f.	Percentage of soil from on-site	0			(1 - d)	0%	
g.	Excavation unit cost (on-site material)	$0.00	/yd3				
h.	Total erosion/protective soil unit cost				(d x e) + (f x g)	$11.65	/yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3				
j.	Compaction unit cost	$0.00	/yd3				
k.	Total soil unit cost				h + i + j	$16.55	/yd3
l.	Erosion/Protective soil subtotal				k x b	$0	
m.	Percent compaction	20%					
	Total Erosion Control/Protective Cover Soil Cost				l x (1 + m)	***$0***	

III. Vegetative support soil (Topsoil)

a.	Area to be capped	0	acres	x 4,840yd2/ac	0 yd2
b.	Depth of topsoil needed	0	inches	x 1yd/36in	0.00 yd
c.	Quantity of topsoil needed			a x b	0 yd3
d.	Percentage of topsoil from off-site	100%			
e.	Purchase unit cost for off-site material	$11.65	/yd3		
f.	Percentage of topsoil from on-site	0		(1 - d)	0%
g.	Excavation unit cost (on-site material)	$0.00	/yd3		
h.	Total topsoil unit cost			(d x e) + (f x g)	$11.65 /yd3
i.	Hauling, Placement and Spreading unit cost	$4.90	/yd3		
j.	Total soil unit cost			h + i	$16.55 /yd3
	Total Topsoil Cost			c x j	***$0***

IV. Vegetative Cover

a.	Area to be vegetated	21.5	acres		
b.	Vegetative cover (seeding) unit cost	$2,350	/acre		
b.	Erosion Control Matting Quantity	0	yd2		
c.	Erosion control matting unit cost	$0.00	/yd2		
	Total Vegetative Cover Cost			a x (b + c)	***$50,525***

Soil Cap Component Subtotal: $1,657,905

Geosynthetic Barrier & Infiltration Layers

V. Flexible Membrane Liner

				Calculation or Conversion	
a.	Quantity of FML needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.24	/ft2		
c.	Installation unit cost	$0.16	/ft2		
d.	Total FML unit cost			b + c	$0.40
	Total FML cost			a x d	***$0***

VI. Geosynthetic Clay Liner

a.	Quantity of GCL needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.00	/ft2		
c.	Installation unit cost	$0.00	/ft2		
d.	Total GCL unit cost			b + c	$0.00 /ft2
	Total GCL Cost			a x d	***$0***

Geosynthetic Layers Subtotal: $0

Drainage Components

VII. Sand or Gravel Drainage

				Calculation or Conversion	
a.	Area to be capped	0	acres	x 4,840yd2/ac	0 yd2
b.	Depth of sand or gravel needed	0	inches	x 1yd/36in	0.00 yd
c.	Quantity of drainage material needed			a x b	0 yd3
d.	Percentage of media from off-site	0%			
e.	Purchase unit cost for off-site material	$0.00	/yd3		
f.	Percentage of material from on-site			(1 - d)	100%
g.	Excavation unit cost (on-site material)	$0.00	/yd3		
h.	Total drainage material unit cost			(d x e) + (f x g)	$0.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3		
j.	Compaction unit cost	$0.00	/yd3		
k.	Total drainage material unit cost			h + i + j	$0.00 /yd3
l.	Drainage material subtotal			k x b	$0.00
m.	Percent compaction	0%			
	Total drainage material cost			l x (1 + m)	***$0***

VIII. Geotextile

a.	Quantity of geotextile needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.00	/ft2		
c.	Installation unit cost	$0.00	/ft2		
d.	Total geotextile unit cost			b + c	$0.000 /ft2
	Total Geotextile Cost			a x d	***$0***

IX. Geonet Composite

a.	Quantity of geonet composite needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.39	/ft2		
c.	Installation unit cost	$0.19	/ft2		
d.	Total geonet composite unit cost			b + c	$0.58 /ft2
	Total Geonet Composite Cost			a x d	***$0***

X. Cap Underdrain System

a.	Length of Cap Underdrain needed	0	LF		
a.	Length of Channel Underdrain needed	0	LF		
b.	Purchase unit cost (Cap Underdrain)	$28.15	/LF		
c.	Purchase unit cost (Channel Underdrain)	$46.75	/LF		
	Total Underdrain Cost			a x d	***$0***

XI. Stormwater Controls

Rip Rap

g.	Quantity of Rip Rap needed	500	ton		
h.	Rip rap unit cost	$55.30	/ton		
i.	*Total rip rap cost*			g x h	*$27,650*

Additional Stormwater Controls

k.	Additional Stormwater Controls	$30,000.00			
	Total Stormwater Control			c + f + i + l	***$57,650***

Drainage Component Subtotal: $57,650

Miscellaneous

				Calculation	
XII.	**Removal and Disposal of Stockpiled Material**				
a.	Quantity of stockpiled CCR	100,000	ton		
b.	Loading and Hauling unit cost	$76.25	/ton		
c.	Disposal unit cost	$0.00	/ton		
d.	***Total Removal/Disposal Cost***			a x (b + c)	***$7,625,000***
XIII.	**Erosion/Sediment Control**				
a.	Quantity of silt fence needed	3,000	LF		
b.	Silt Fence unit cost	$2.05	/LF		
	Total Silt Fence Cost			a x b	***$6,150***
XIV.	**Site Security**				
Fencing					
a.	Length of fencing needed	-	ft		
b.	Fence unit cost	$0.00	/ft		
c.	*Subtotal fencing cost*			a x b	*$0*
Gate or Barrier					
d.	Number of gates required	-			
e.	Gate unit cost	$0.00	/gate		
f.	*Subtotal gate cost*			d x e	*$0*
Closed Sign					
g.	Number of signs required	-			
h.	Sign unit cost	$0.00	/sign		
i.	*Subtotal sign cost*			g x h	*$0*
	Total site security cost			c + f + i	***$0***
XV.	**Mobilization / Demobilization**				
a.	Cost for mobilization/demobilization	$41,000			
	Total mobilization/demobilization cost				***$41,000***

Miscellaneous Subtotal: **$7,672,150**

Closure Cost Subtotal (CCS):	(I + … + XIX)	$9,387,705	
Contingency (8%):	CCS x 0.08	$751,016	
Engineering & Documentation:			
Construction QA/QC (10%)	CCS x 0.10	$938,771	
Closure Certification and CQA Report (1%)	included above	n/a	
Survey and as-builts (2%)	included above	n/a	
Construction Documents (1%)	CCS x 0.01	$93,877	
Cost for survey and deed notation		$7,500	
Total Engineering & Documentation Costs		***$1,040,148***	
Total Closure Cost:	CCS + Contingency + Engineering		**$11,178,869**
	Per acre closure cost estimate		**$519,947.40**